DENGUE IN FINNISH INTERNATIONAL TRAVELERS, 2016–2019

– A retrospective analysis of places of exposure and the factors associated with the infection

M.Sc.-thesis

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ABSTRACT

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Abstract:
As an emerging infectious disease dengue is putting a constantly growing number of international tourists at risk of the infection. To have a more complete picture of the phenomena among the Finnish travelers, the backgrounds of infections were retrospectively examined to find out the place of exposure, type of traveler and the trip, risk perceptions and protective measures taken. The study period was from January 2016 to May 2019 and reported dengue infections from this period were obtained from the National Infectious Disease Register, which is maintained by the Finnish Institute for Health and Welfare (THL). The questionnaire both in Finnish and Swedish was sent to the participants. The response rate in this study was 61.3 %.

Data was analyzed spatially with QGIS 3.4.8 Madeira and statistically by using R 3.6.0. Descriptive statistics were used to analyze the demographic variables as well as answers given to the questionnaire. In addition, two binary logistic models were fitted to find out statistically significant factors for risk perception and the use of protective measures. Crude attack rates were calculated for different destinations using UNWTO travel data. Further on, the results were compared to existing literature related to this research.

Thailand and Indonesia were identified as destinations with the most abundant number of infections imported to Finland. However, Maldives had the highest crude attack rate per 100,000 travelers. The type of travel during which the infections were acquired was mainly pre-booked holiday of 14 days with time spent mostly on the beach. Most of the travelers were not aware of the dengue risk before the travel and did not seek pre-travel advice. Those who sought pre-travel advice were 34.9 times more likely to use protective measures than those who did not. Moreover, the majority applied some protective measures but not during the right time of the day, and thus the measures were chosen incorrectly.

Based on these results the knowledge about dengue, day-active/urban mosquito and the correct use of protective measures needs increasing. Further on, the risk within touristic destinations requires highlighting and the distinction between malaria and other mosquito-borne diseases could be made clearer. In addition, there is a need to increase the knowledge of dengue among healthcare workers.

Further information: This dissertation was done as a project for Finnish Institute for Health and Welfare (THL).

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CONTENTS

ABBREVATIONS

AR – Attack Rate

DENV – Dengue virus

DHF – Dengue hemorrhagic fever

DSS – Dengue shock syndrome

ECDC – European Centre for Disease prevention and Control

EEA – European Economic Area

EU – European Union

GIS – Geographic Information Systems

IAMAT – International Association for Medical Assistance to Travelers

OSF – Official Statistics of Finland

RS – Remote Sensing

TESSy – the European Surveillance System

UNWTO – United Nations World Tourism Organization

WHO – World Health Organization

INTRODUCTION

Dengue is the most common and single most important arbovirus infection globally, with the transmission in at least 128 countries and more than half of the world population at risk (Stanaway et al. 2013). In 2019 World Health Organization (WHO) listed dengue among the ten biggest threats to global health as the burden of dengue is enormous and constantly growing (WHO 2019a). However, the nature of dengue leads to underdiagnosing as well as to misreporting and thus sets challenges into making efficient interventions (Castro et al 2017).

As an arbovirus, dengue is a vector-borne disease and is transmitted by daytime active mosquitoes belonging to the family *Aedes*. In recent years the prevalence of vector-borne diseases has increased considerably due to intensification and geographical expansion of the human population, increased travel and the trade, intensification of agriculture, and the disturbance of habitats caused by climate change and deforestation (Mayer et al. 2016, WHO 2017a). This has contributed to the introduction of vector-borne diseases such as dengue, into new geographical areas with the virus being transported from one place to another by infected travelers (Sigfrid et al. 2018). During the past four decades, dengue has been noticed in new geographical areas with increasing frequency and in 2002 it was noted that more than 100 countries have endemic dengue fever (Gubler 2002, Gubler 1997). Compared to this, currently there are at least 128 dengue-endemic countries and the estimation of a number of cases yearly has changed from 100 million to 390 million cases (Bhat et al. 2013, Stanaway et al. 2013).

Due to the intensification of dengue distribution, one of the population groups at risk is the constantly growing number of international travelers. Many dengue-endemic countries are popular touristic destinations and via international travel the disease is further transmitted into new geographical regions with established vector-population, such as Europe, highlighting the need for research of importation patterns (Polwiang 2016:399). Globally the number of arrivals a year has increased from 500 million to 1.34 billion from 1995–2017 (World Bank 2019, Zöldi et al. 2017). One of the regions with the biggest increase is Europe.

Moreover, the increase in travelers can be seen in Finland as well. The leisure travels among Finns have increased considerably during this time and thus there is a constantly growing number of Finnish travelers visiting the dengue-endemic countries and being at risk of dengue infection (OSF 2019a).

There are no previous studies regarding backgrounds of dengue infections among Finnish travelers and very little study about tropical vector-borne diseases and attitudes towards travel health in general among Finns. Hence, it is essential to investigate the backgrounds of recently acquired infections to improve the recommendations regarding global travel and to fill the possible gaps in knowledge in regards to different vector-borne diseases. Even though the possibility of introduction of autochthonous dengue transmission in Finland does not exist at the moment, it is in general important to discover the risks that tourism carries, to make interventions to reduce the risk and to prevent the autochthonous transmission in Europe and other areas that are in risk of emerging or re-emerging dengue.

OBJECTIVES

This thesis is done as a project for Finnish Institute for Health and Welfare (THL) and it is based on the need to complete the information in the National Infectious Diseases Register (NIDR) with missing information of countries where the infections have been contracted. Therefore, the main objective of this study is 1) to retrospectively examine the countries from where the dengue cases are imported to Finland in January 2016–May 2019 and to analyze the geographical risk areas in disease importation.

There are no previous studies analyzing the backgrounds of dengue or other tropical vector-borne infections among Finnish travelers. This in mind, this study is also aiming to map out the backgrounds of most recently acquired infections to form a comprehensive picture of the factors associated with contracting the disease. Therefore, in addition to places where the infections have been acquired it is important to find out 2) which are the factors associated with the risk for contracting dengue fever among Finnish travelers and what is the risk group for dengue among Finnish travelers. In addition, examining how and when the protective measures have been applied is important in order to target the intervention methods effectively. Therefore 3) the risk perceptions prior to travel and the protective measures taken to minimize the probability of contracting dengue will be investigated. It will be also noted how the independent variables are associated with seeking pre-travel advice and with the activity in using protective measures to prevent mosquito bites. As this thesis seeks to understand and define the risks that are related to dengue infection, also the crude attack rates for infections per destination countries will be examined.

The results of this study will be used to complete the information related to dengue infections contracted during January 2016–May 2019 in Finnish National Infectious Diseases Register. Based on these results, different intervention strategies can be created to increase the knowledge about different vector-borne diseases, to target the right audience with pre-travel advice and further to prevent Finnish travelers from acquiring dengue infections.

BACKGROUND

Geographies of health and epidemiology

Geographies of health and epidemiology are closely related to each other. It is said that the simplest way to understand the geographies of health as a concept is to contrast it with epidemiology. Epidemiology is for medicine the same thing than geographies of health is for geography, the difference can be found through the standpoint of view which is more regional with geographies of health than it is with epidemiology (Löytönen 2004).

The contribution of geographers to the understanding of diseases has been increasing throughout the time (Howe 1977). The history of health geography can be seen to start as early as the antic creek with Hippocrates´ work (Solin 1986). However, the modern health geography started developing in the 1790s with *Versuch Einer Allgemeinen Medizinish Praktischer Geographie* by Leonhard Ludvig Finke (Löytönen 2004: Härö 1992). The next step was taken by August Hirch in the 1880s by stating that the incidence and the prevalence of diseases are different among different geographic areas (Löytönen 2004). Hirchs way of thinking already has a lot in common with epidemiology and when looked form the epidemiology point of view, the similarity with geographies of health can be seen as well. John Snow, who is said to be the father of epidemiology, did his most famous work by mapping out the cholera cases to investigate the origin of the disease (Vineis 2018). Geographies of health and epidemiology are therefore sharing a lot of common ground and are bonded together throughout history.

In 2002 Kearns and Moon published an article analyzing the change of earlier more medically defined branch of geography into new health geographies with a wider picture of health as a concept. According to them, the change has happened over the past decade and it has been a shift from medical to more comprehensive health geography. They state that this new health geography contains “wider academic landscapes of geography and health-related research.” (Kearns & Moon: 2002). Thus the health geography is taking a step further from classic research of diseases and covering more and more different phenomena related to health.

The same kind of shift can be seen in epidemiology as well but on a smaller scale and a lot earlier than in health geography. Originally epidemiology was only comprehended as a study of the nature of different infectious diseases, epidemics and the prevention of these diseases (Andresen & Bouldin 2010:6, Teppo 1997). Later the concept was expanded to embody the diseases and other health-related conditions′ prevalence, incidence, and change in time and space, as well as the study of risk factors, related to those. Among others, one goal for epidemiological research is to find methods to prevent diseases (Brownson & Petitti 1998:4, Teppo 1997). In general, epidemiological research tries to answer the following two questions according to Uhari & Nieminen 2012; How health-related phenomena and problems are distributed among different population groups? Which factors seem to increase the risk of the disease? Kauhanen et al. (1998) conclude that descriptive epidemiological research supports evaluating and prioritizing public health problems regarding their significance. The constant surveillance reveals the changes in public health and offers the opportunity to react to these changes and therefore benefits the government and the political decision-making (Kauhanen et al. 1998:118).

The epidemiological study is aiming to evaluate the crucial factors affecting the origins and development of diseases (Uhari & Nieminen 2012:118) whereas geographies of health focus more strongly on the geographical point of view but is still researching the same fields. The geography side-of-view could be concluded perhaps in the following way: “Almost everything that happens, happens somewhere. Knowing where something happens can be critically important” (Longley et al. 2011:4).

Also in this study, knowing where the infections are acquired is critically important in the understanding of the distribution patterns of different diseases. However, even though this is a crucial part, it alone does not provide enough information on understanding why these regions are source of infections. We also need to understand the ecological, biological and health-related aspects, as well as tourism and global movement in general. This study combines geography, epidemiology and also biology by utilizing the ideas, theories and methods of these disciplines.

GIS in a study of vector-borne diseases

GIS is a good way of revealing otherwise invisible in geographic information (Longley et al. 2011:16). Geographic Information Systems (GIS) have been widely used in the study of vector-borne diseases. According to WHO, Vector-borne diseases are infectious diseases that are transmitted via living organisms, usually bloodsucking insects. These diseases can be transmitted between human to human or from animal to human by the insect ingesting pathogenic microorganisms with biting infected host, and later injecting a new host the same way (WHO 2017b). The best-known vector is a mosquito, and others usually insects such as sandflies, ticks, fleas, and triatomine bugs.
There are several techniques for modeling the suitability of the environment for the vector-organism or the disease itself (Cianci et al. 2015:2). Among GIS-methods remote sensing- techniques to model the suitable environment are commonly used, but GIS is also used for identifying the spatial and space-time patterns of infections. The goal with these GIS techniques in the study of vector-borne diseases is to find ways to make predictions, estimate and lighten the disease burden (Cianci et al. 2015:2, Eisen & Eisen 2010:42).

However, these technologies have not been used to their maximum potential and GIS has not yet received the attention it deserves in the study of vector-borne diseases (Eisen & Eisen 2010, Eisen & Lozano-Fuentes 2009:1). In general, the error, inaccuracy, vagueness, and ambiguity in the data increase the uncertainty with GIS modeling (Longley et al. 2011: 148) and problems are often rising from the lack of comprehensive data, which makes the accurate modeling difficult to carry out (Rochlin et al. 2011:7). As the variables affecting the vector-borne disease distribution are complex including social, economic and biological factors, the need for comprehensive data is extensive (McMichael 2006). Eisen & Eisen (2010) argue that the most important aspect with mapping diseases is that outputs are as good as the data they are based on. It has been stated that models developed for vector-borne diseases are often too conceptual and technically too complex to interpret easily (Rochlin et al. 2011:7).

When it comes to mapping environmental suitability for vectors, especially with mosquitoes, the problem is that they often breed in water-containers which require such fine-scale aerial photographs that it presents a major obstacle for RS imagery. In addition, the water containers are not directly influenced by environmental factors, ergo mapping with for example Normalized Difference Vegetation Index, doesn´t indicate areas for vector breeding suitability (Eisen & Lozano-Fuentes 2009). However, technologies are constantly developing and thus tools for GIS-methods improving.

Although, the mapping of suitable areas for vector- species might provide valuable knowledge, the density of vector-populations doesn´t directly indicate the volume of infections. Specifically, this is the case with dengue fever since there might be a herd immunity against certain serotypes of the virus and some of the serotypes are known to be more infective than others (Eisen & Lozano-Fuentes 2009:2). Hence, the mapping with epidemiological data with diagnosed cases provides information on the actual dengue risk. The most accurate way of showing spatial data of infections is to map locations of each case point (Eisen & Eisen 2010:52). Yet, this is often difficult due to sensitivity of health data and specifically with dengue, the problem arises from the number of asymptomatic cases. Nonetheless, the cases diagnosed indicate the occurrence of the disease and thus provide the best possible knowledge of the actual risk.

With increased international travel and the ongoing climate change, the importance of mapping and predicting suitable environments for different vector-species is constantly being emphasized (Bouattour et al. 2019, Cianci et al. 2015). GIS-based modeling has been proven to be effective with informing policymakers and other stakeholders as maps are known to be strong tools for information delivery (Eisen & Eisen 2011:55, Eisen &Lozano-Fuentes 2009). Thus, it is important to study the potential threats that emerging or re-emerging diseases possess to global health.

Climate change and vector-borne diseases

As mentioned earlier, with understanding the diseases such as dengue, it is also needed to understand other phenomena related to it. In this case, climate change has a significant role affecting to the disease in multiple different ways. As Weiss and McMichael (2004) state, also the social, economic and ecological factors influence on vector-borne diseases, which are all influenced by climate change. Since vector species play key role with the distribution of dengue, it is important to understand what they are, how climate is controlling their behavior and distribution, and what kind of influence it has on biological vectors. It requires understanding from molecular to population-level only to understand the functions of the arthropod-pathogen-host cycle and its relation to climate change (Tabachnick 2010). Climate change is emphasizing the need to conduct further studies of vector-borne diseases and strengthen the surveillance in order to prevent the diseases from spreading into new regions in the future. It is also acting as an initial inspiration for this thesis.

In dengue, the ecology of a vector is inseparable from distribution and transmission of the diseases, and many vector organisms are sensitive to climatic conditions (Pascual & Dobson 2005, Reeves et al. 1994). Climate change will change the geographical distribution of vector species and therefore will have an influence on the geographical range of dengue as well as on the potential incidence and seasonal transmission (Caminade et al. 2019, Costello et al. 2009, McMichael et al. 2006). Among vector-borne diseases in general, we may be able to see the first impacts of climate change, regardless of whether the transmission will increase or decrease (Rogers et al. 2014: 2).

From the complexity of the role of climate change, the good example is poverty, which is influenced by climate change and further on has a major effect on the distribution of diseases (Tabachnick 2010). Partly related to poverty, the spread of disease, access to care, treatment, and prevention of illness are unevenly distributed across the globe and the substantial progress in global health improvement has been significantly unequal.

According to McMichael et al. 2006, the environmental effects of climate change can be categorized into four categories which each have further impacts on human health: Extreme weather events, the effect on ecosystems, sea-level rise and environmental degradation. These categories especially the second is associated to vector-pathogen-host relations and infectious disease geography and seasonality (McMichael et al. 2006).

The way pathogens interact with the arthropod vector and the human host is dependent on climate (Tabachnick 2010). Only the temperature alone affects the transmission significantly. On an insect level, arthropods are ectothermic and thus regulated by the external conditions (Caminade et al. 2019). For example, if water temperatures rise, the mosquito larvae take a shorter time to mature and vectors will also have a greater capacity to reproduce during one transmission period (Githeko et al. 2000). Moreover, the probability of transmission is also increased by the warmer temperatures by shortening the time for mosquitoes to digest blood and making it feed more frequently (Githeko et al. 2000: 1137). Furthermore, the viruses complete the extrinsic incubation within the mosquito, and it becomes infectious faster (Hales et al. 2002). With the temperature close to the upper threshold the vector biting rates are increased as well, whereas after exceeding the upper limit, they decrease and can increase the mosquito mortality and hence decrease the risk for dengue infection (Ebi & Nealon 2016:118, Scott et al. 2000).

Other climate-related factors affecting the behavior of the mosquito are such as humidity and evaporation. Regarding Ebi and Nealon (2016), these as well as temperature, affect the vector competence, biting behavior and adult mosquito survival. A study executed by Campell et al. 2013 states that temperature defines the suitable range for transmission and humidity determines the potential within that range (Campell et al. 2013).

However, it depends on the non-climate factors if the change in transmission actually occurs, since the transmission is greatly affected by socioeconomic conditions and the capability of public health (McMichael et al. 2006, van Lieshout et al. 2004). Most vector-borne diseases can be prevented by vector-control if it is implemented well (WHO 2017a). Along with climate change, new control efforts are needed to cope with the potential consequences that it has on the geographical distribution and incidence of vector-borne diseases such as dengue (Ebi & Nealon 2016).

DENGUE AS A DISEASE

Dengue infection

Dengue is a viral disease and the dengue virus (DENV) has four distinct serotypes (DENV1–DENV4). It is a vector-borne disease and transmitted via *Aedes*- mosquitoes. On rare occasions, dengue can be transmitted by other routes like a transfusion of blood or organs (Chen & Wilson 2010, Tambyah et al. 2008).

The incubation period for DENV is usually 4–7 (range 3–14) days (Chen & Wilson 2010:440, Siikamäki et all 2003: 2055). Dengue fever causes flu-like symptoms, and a major part of infections occurs either asymptomatically or with mild febrile symptoms, approximately one in four patients show any signs of disease (Castro 2017). Dengue has a wide spectrum of clinical presentations of high fever, pain behind the eyes, headache, muscle- and joint pain. On some occasions, severe myalgia can occur known as “break bone”-fever (Lumio 2018, Chen & Wilson 2010, Tsai 2000). To the spectrum of symptoms are also included gastrointestinal symptoms, like nausea and vomiting (Chen & Wilson 2010). The fever usually lasts from 3 to 7 days, and after the start of fever three out of four patients develop a rash on limbs or redness to the upper body (Lumio 2018). As mentioned, the disease can also be almost or completely asymptomatic with “silent transmission” (Gubler 1998:487). For example, in 1974 the virus circulated in an island of Tonga in Pacific for nearly a year before being detected (Gubler et al. 1978). Due to this kind of asymptomatic transmission, the absolute burden for public health is impossible to estimate. Dengue in its severeness is comparable to seasonal influenza.

Long-lasting immunity to DENV serotype is produced after the infection of that certain serotype (Chen & Wilson 2010). However, if after the first dengue infection the person gets infected with another serotype of DENV, it might develop into a severe dengue with a hemorrhagic fever (DHF) or dengue shock syndrome (DSS), this happens in approximately less than 5 % of the cases and even more rarely among travelers (Chen & Wilson 2010, Weichmann & Jelinek 2003). The risk group for severe dengue is especially the people with asthma, diabetes and other chronic diseases (Guzman et al. 2010). In endemic areas, people are under the risk of dengue from the beginning of their life, and infections caused by multiple serotypes are more likely compared to travelers (Siikamäki et all 2003: 2055). The death rate with DHF and DSS is remarkably higher than with the normal dengue fever and the World Health Organization estimated that approximately up to 20 % of untreated severe dengue cases lead to death (WHO 2019b). WHO´s dengue control strategy aims to reduce deaths by 50 % by 2020 (WHO 2019b).

The development of dengue vaccine has been active, and the first dengue-vaccine was licensed in 2015. Currently, the vaccine is only aimed for the population aged between 9–45 years in endemic areas and has been infected with dengue before (Guy et al. 2017). As this vaccine has its limits, and there is no suitable vaccine for travelers, the development of the dengue vaccine is constantly driven by the economic burden of dengue and the concerns of environmental impacts of spraying the mosquitoes and the evolution of mosquito resistance to insecticides (Ranson et al. 2011).

Dengue virus and its cycle

Systemic infection of dengue is caused by a mosquito-transmitted, single-stranded RNA virus of the genus *Flaviviridae* (Castro 2017, Patterson et al. 2016:672). Flaviviruses are small capsuled RNA- viruses with 10 000 base-paired genomes (Siikamäki et al. 2003: 2052, Gubler 1998:483). There are four serotypes of dengue virus (DENV) which differ serologically and genetically from each other. Type 2 is considered to be the most virulent strain (Patterson et al. 2016: 672). Having had one infection caused by one serotype does not give immunity against other serotypes than the one infecting the patient, but moreover increases the chance of having severe dengue. This is due to cross-reaction where the IgG (immunoglobulin) antibodies from earlier dengue infection start forming immunocomplexes with the infecting DENV (Halstead 1988).

As stated before, dengue fever is an arboviral, vector-borne disease and the dengue virus is transmitted by *Aedes* mosquitoes from people to people. The mosquito can bite multiple people during a fly (Siikamäki et al 2003) and if one of these people is viremic, it takes from 5 to 33 days at 25 degrees for viruses to multiply, mature and migrate to the salivary glands of the mosquito. Only after this can mosquito transmit the virus to another person, but once infected, it can do so until the end of its life (Ebi & Nealon 2016: Chan & Johansson 2012, Gubler 1998: 484).

If infective mosquito then bites the next person, the patient becomes viremic and shows symptoms after 3–14 (average of 4–7) days of the incubation period. This is followed by an acute febrile period of variety nonspecific symptoms which takes from 2 to 10 days and during which the dengue viruses may circulate in the peripheral blood (Gubler 1998:484). If other *Aedes*-mosquitoes bites the person during this stage, mosquitoes may become infected and therefore transmit the virus further on (Gubler 1998:484).

The virus can`t be transmitted directly from human to human, except in some cases from mother to unborn child, blood transfusion or organ transplantation from viraemic donors (ECDC 2018a, Punzel et al. 2014, Chen & Wilson 2010, Tambyeh et al. 2008). These cases are rare but happen, requiring knowledge from healthcare workers.

Laboratory diagnosis of dengue infection relies on the identification of the virus, viral antigen or dengue-specific antibodies (Vapalahti & Vaheri 2003). Detecting antibodies can be done five to six days after fever onset, in secondary dengue infection antibodies normally appear earlier. Serological cross-reactions between dengue and closely related flaviviruses, such as Japanese encephalitis and West Nile virus, are frequently reported and common in serologic tests used to diagnose DENV (Chen & Wilson 2010:439). This complicates the detection of dengue fever (ECDC 2012).

Dengue virus, as most arboviruses are, in addition to the human population, also circulation among nonhuman primates in a sylvatic cycle (Chen & Wilson 2010, Cardosa et al. 2009, Wolfe et al. 2001). These viruses rarely infect humans, but people who accidentally intrude these cycles might be infected, in rare cases, viruses may jump from the sylvatic transmission cycle into the human-mosquito transmission cycle. Nonhuman primates have a clear role in maintaining the cycles of certain flaviviruses, such as dengue and yellow fever, but the public health implications of sylvatic cycles remain complex as infections caused by the sylvatic cycle are less virulent than those originating from humans (Wolfe et al. 2001). Before dengue spread globally, it has been most likely been jumping form sylvatic cycle to humans now and then causing small outbreaks. Only after the population growth and the disturbance of the forest habitats, the virus spread more efficiently causing large outbreaks globally.

Surveillance of dengue in Finland

Dengue surveillance in Finland is based on passive surveillance which involves national notification systems that are based on obligatory case reporting; health providers and laboratories have to routinely report the incidence of an infectious disease without being actively requested to do so (Ouagal et al. 2010). Passive surveillance provides information on the entire population and requires a limited amount of resources. Dengue fever is not part of infectious diseases that needs to be actively monitored in Finland; however, it belongs to the group of infectious diseases that needs to be reported to the National Infectious Disease Register (NIDR) when diagnosed, according to the Infectious Disease Act (Finlex 2019).

The diagnostics are focused in the capital area in Finland, and the samples are investigated only by the laboratory at the University of Helsinki and virology-department of laboratory diagnostics in Helsinki University Hospital (Vapalahti et al. 2003: 2051–2061). Dengue infections have been reported to NIDR from 1999 onwards.

THE PAST AND PRESENT DISTRIBUTION

The spread of dengue in the history

The earliest evidence of dengue-type of the disease has been found in the Chinese medical encyclopedia from AD 265–420 (Mayer et al. 2016:158). It was also described in Panama in 1699 (Howe 1977). Following this, the dengue-like illness has been described throughout the different continents during the 16th century (Mayer et al. 2016:158).

Due to the deforestation and agricultural settlements in the jungle, the dengue virus was most likely to emerge into the human population in Asia (Mayer et al. 2016:158). The geographical distribution expanded from the origin by the virus jumping into a human cycle most likely by the disturbance of forest-areas and the human migration and trade as commerce developed, made it possible for the virus to spread globally. It has been stated that the World War II created ideal surrounding for the global transmission via solders with no immunity traveling around the world from the endemic areas (Wolfe et al. 2001:312, Gubler 1998:481). However, even before this global spread, epidemics of dengue have been noted in Europe, such as in Greece in 1927–1928 with a large outbreak (van den Berg et al. 2013:2). Soon after this the vector and the disease disappeared from Europe. Dengue hemorrhagic fever, however, have been first discovered in the Philippines in 1953 and a few years following this, it was also found in other parts of Southeast Asia as well (Siikamäki et al. 2003).

During 1960–1970 dengue fever spread within endemic areas form bigger cities into smaller cities and became cyclic with larger epidemics once every 2–5 years (Siikamäki et al. 2003). In the 1980s and 1990s the distribution area included already India, Sri Lanka, Pakistan, and China, and before 1970 total of only 9 countries had experienced severe dengue epidemics (WHO 2019b). From 1970 onwards dengue spread into South America with high volume due to reduces in insecticides and when at the beginning of the 1980s there was first recorded infection in Cuba, in the 1990s there were already tens of thousands of reported cases in South America (Siikamäki et al. 2003). In 1997 dengue virus had a worldwide distribution in tropics and over 2,5 billion people lived in an endemic area (Gubler 1998:481). In temperate areas, the development of public health and the improvement of construction among other things have erased dengue in the history, but new challenges are encountered as international travel and trade are increasing the risk of introduction or re-introduction of the disease (Rogers et al. 2014:2).

Current distribution of dengue

The burden of dengue is considerable and the World Health Organization (WHO) has earlier estimated that the number of dengue cases being approximately somewhere between 50–100 million a year. This number is still widely used, and it is based on estimations of reported cases. However, dengue cases are underreported and misclassified, and the actual number of cases is remarkably higher than this estimate. The true number of cases is later estimated to be 390 million (Bhat et al. 2013).

To date, dengue is one of the most rapidly spreading mosquito-borne diseases in the world. WHO states that during the last 50 years the disease has expanded geographically to new countries and from urban to rural settings, also during this time, the incidence for dengue has increased 30-fold (Schaffner & Mathis 2014, WHO 2009:15). More than half of the world population lives in dengue transmission risk- area and mostly the disease is present in the tropics (Castro 2017, Brady et al. 2012).

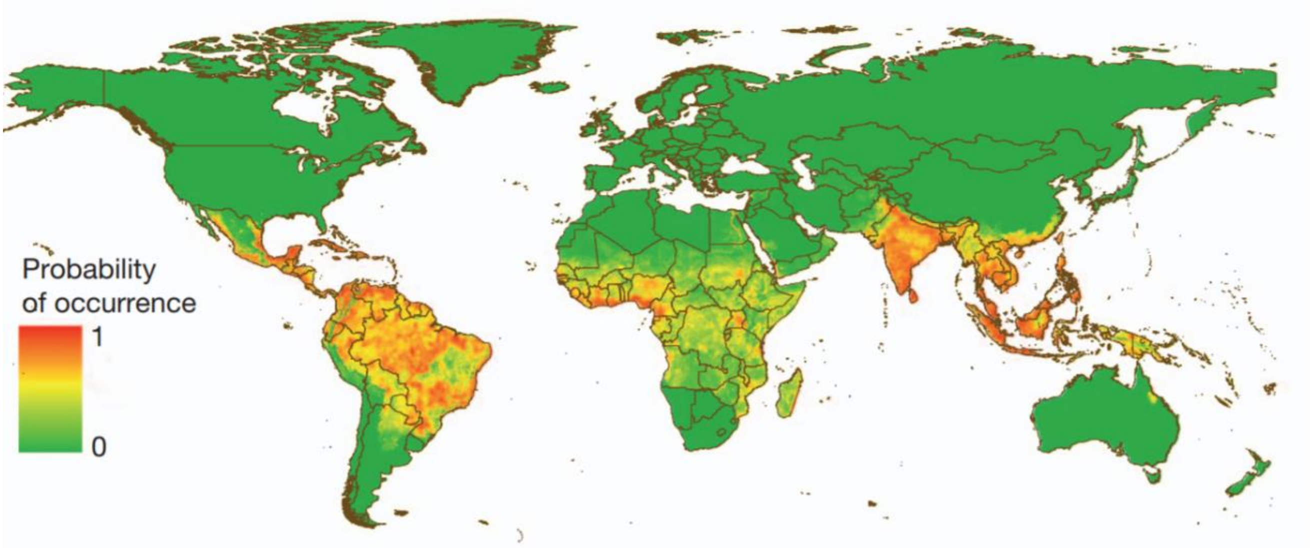

Figure 1. Probability of dengue occurrence at 5km x 5km spatial resolution by Bhatt et al. 2013.

Based on widely used estimations of Bhatt et al. (2013) the burden of dengue is most notable in Asia, with approximately 66.8 million apparent and 204.4 million inapparent cases a year. In this area especially India and Indonesia are standing out with 7.5–32.5 million annual infections and with the highest probability of occurrence (Bhatt et al. 2013:506). The second highest burden is in Africa with approximately 15.7 million apparent and 48.4 inapparent cases a year, following Americas with the same numbers being 13.3 million and 40.5 million a year (Bhatt et al.2013:506). The burden of dengue is thus undoubtedly significant in Asia compared to other continents.

From the 1980s dengue has been noticed in new geographical areas with increasing frequency (Gubler 1997). Especially unplanned urbanization, increased global travel and trade, deforestation and climate change possess a significant risk on the extensive increase of dengue fever distribution (Ebi & Nealon 2016: 119, van den Berg et all 2013, WHO 2017a). Regarding Ebi and Nealon 2016, the temperature is an important factor limiting the absolute geographic limits of dengue transmission, but it also affects the level of endemicity (Ebi &Nealon 2016).

It has been showed that the reported number of dengue infections as with other vector-borne diseases have been highly correlated with human population growth (Gubler & Meltzer 1999). Due to the complex nature of vector-borne pathogens it is normally challenging to predict whether the disease is going to re-emerge or not, but with dengue, its intensification seems rather clear since its vectors are closely associated with urbanization (WHO 2017a).

WHO concludes that there have been explosive outbreaks of dengue during recent years around the world. The year 2016 was characterized by large outbreaks throughout the world, in Brazil with 1.5 million, Philippines with 176 411, Malaysia with 100 028 and Burkina Faso with an outbreak of a size of 1 061 cases (WHO 2019b). Again in 2019, there has been an increase in cases worldwide (WHO 2019b) and the number of infections seems to be rising in some of the endemic countries noticeably from 2018. According to the ECDCs Communicable diseases threats report (CDTR), dengue infections have increased in 2019 compared to the same period in 2018 (ECDC 2019a). Especially Southeast Asia stands out with increased numbers in infections. For example, in September Thailand reported 85 520 cases compared with 37 000 for the same period in 2018, Laos 24 758 cases compared with 4 400 in 2018 and Malaysia 96 300 compared to 53 800 in 2018 (ECDC 2019a, ECDC2018b). The most significant increase in dengue cases has been seen in Brazil, as the increase is more than ten-fold only during 2018–2019. In September 2018 the number of cases was around 198 000 and at the same time in 2019 it has gone up to 1 960 000 cases. Brazil accounts for the highest number of cases as an individual country in 2019. These numbers, of course, do not fully represent the long-term trend in the number of cases, but they highlight the current situation in the geographical areas around the world and in the regions that are also in favor of global tourism.

In general, the reported number of deaths caused by dengue is yearly around 20 000–25 000 cases (Lumio 2018). However, many dengue-endemic countries have insufficient data about dengue-related deaths (Stanaway at al 2016). This uncertainty about dengue burden challenges specialists and policymakers in their ability to set priorities, plan resources or make interventions (Castro et al 2017). It represents a growing challenge to public health and the key to tackling the threat is to strengthen the evidence base on which the decisions of planning and making interventions are grounded on (Bhatt et al. 2013: 507).

Dengue transmission

The epidemiology of dengue fever is in an inalienable relationship with the vector ecology. The transmission has distinct patterns that reflect the relationship between the climate, the mosquito, the virus and the population immunity (Castro 2017). These patterns are both seasonal and cyclical.

Only female mosquitoes bite and can, therefore, transfer the virus. It is notably that *Aedes* mosquitoes do not only carry and transmit other diseases caused by flaviviruses such as yellow fever and zika-virus, but also alphaviruses, bunyaviruses and phleboviruses causing diseases such as chikungunya and Rift Valley fever (Valerio et al 2015:416, Chen & Wilson 2010). *Aedes* mosquitoes bite during the day, with a peak biting period being in the morning and late afternoon (Wilder-Smith & Schwartz 2005). They are also indoor feeders and can be found in dark areas such as in bathrooms and under beds (Wilder-Smith & Schwartz 2005).

The most effective protective measure is to prevent *Aedes*- mosquitoes from biting by wearing protective clothing and using insecticides or insect repellents containing DEET (N,N- diethyl-3-methylbenzamide) (Wilder-Smith & Schwartz 2005). The repellents are usually oily substances whose odor induces the mosquitoes to move the opposite direction from the skin (Hasler et al. 2019:27). DEET is considered to be the most effective repellent worldwide and recommended by WHO. To create an efficient protection, the amount of the repellent applied should be sufficient enough (Hasler et al. 2019).

Dengue virus is mainly transmitted from person to person in city-surroundings (Siikamäki et al. 2003). This is due to the primal vector *Aedes aegypti*, which thrives in city-like surroundings and it is found between 35.northern and 35.southern latitudes (Siikamäki et al 2003). *Aedes aegypti* has evolved to live its entire life cycle closely to humans (Patterson et al. 2016) originally due to that humans began storing water in containers and in this way provided perfect surroundings for breeding (Tabachnick 2010:946). It is also highly anthropophilic and usually feeds on multiple people before having enough blood (Rezza 2012). Moreover, the mosquito is a nervous feeder and is easily disturbed and will, therefore, continue feeding on another person (Chen & Wilson 2010). This increases its ability to infect multiple people and therefore the intensity of outbreaks as well (Patterson et al. 2016, Gubler 1998, Kuno 1997). In Europe, *Aedes aegypti* is not present in the continental EU/EEA, but it is present around the Black Sea, and has been historically established in Portugal and in Spain from the 1950s (ECDC 2019c, van den Berg et al. 2013:3, ECDC 2012, Scholte et al. 2010).

Another emerging vector is *Aedes albopictus,* also known as Asian tiger mosquito which is considered as one of the most invasive mosquitoes in regards to public health (Bowman et al. 2016:3, Semenza et al. 2014). It is not as competent vector as *Aedes aegypti*, because it is not feeding primary on people and is not as well adapted to urban environments (Rezza 2012, Chen & Wilson 2010). However, it copes better with a colder climate and is thus a potential threat in higher latitudes such as Europe (ECDC 2018a). Due to its ability to adapt to temperate climates, the global distribution of *Aedes albopictus* is changing quickly and consequently, it is said to have greater capacity for dengue virus transmission than *Aedes aegypti* (Ebi & Nealon 2016: 117, Rezza 2012). Nevertheless, it is still considered as a secondary vector for dengue.

Aedes albopictus eggs are specifically hardy and can therefore survive through winters and slow-moving global transport, which assists its geographical expansion (Ebi & Nealon 2016: 117). Mosquitoes are transported to new geographical areas via global trade, especially used tires, which can contain still water and create an ideal place for eggs and larvae (Rezza 2012). Since the 1970s *Aedes albopictus* has become increasingly established in European countries, mainly because of the global trade of tires. It is strongly established in Bulgaria, France, Greece, Italy, the Netherlands, Slovenia, and Spain, but also in the neighboring countries like Albania, Bosnia-Herzegovina and Croatia (ECDC 2012).

Local dengue transmission in Europe is quite rare but small outbreaks have happened during the last 10 years (Semenza et al. 2014). Autochthonous cases of dengue occur occasionally in Europe in the regions where mosquitoes of the family *Aedes* have become established. The biggest risk is within the areas where *Aedes albopictus* have been established and during the season when *Aedes albopictus* are active and temperatures are favorable (ECDC 2018a). Autochthonous dengue cases were detected in 2010 in France for the first time in Europe after outbreaks in Greece in the1920s (La Ruche et al. 2010). After this, small outbreaks have been detected also in Croatia and Spain (Gjenero-Margan et al.2011). In 2012, the first major dengue outbreak in the European area was reported in Madeira. This outbreak had over 2 100 cases and with 78 cases introduced into 13 other European countries via travelers (Wilder-Smith et al. 2014).

All these outbreaks have been caused by viremic international travelers arriving in Europe from dengue-endemic countries (Semenza et al. 2014). In addition, WHO states that the frequency of outbreaks have increased in the WHO European region due to the spread of vector-mosquitoes (van den Berg et al. 2013.)

A study done in 2016 states that climate conditions might become increasingly suitable for dengue transmission in southern Europe in the future (Liu-Helmersson et al. 2016). As the vector is being present in the areas and there are thousands of tourists arriving from dengue-endemic countries to these areas yearly, it is highly important to have effective surveillance for following the situation. WHO has published a strategic approach for surveillance and control of emerging infectious diseases such as dengue fever in the WHO European Region (van den Berg et al. 2013).

GLOBAL TRAVEL AND DENGUE

Global travel and tourism

The global travel has increased from 1950 with 25 million travelers to 2017 with 1.34 billion (World Bank 2019, Glaesser et al. 2017) and it is predicted to increase by up to 1.8 billion by 2030 (UNWTO 2011). In a world of increasingly extensive movement of people, global tourism is a phenomenon that encapsulates the forces of mobility and freedom but also immobility and inequality (Bianchi 2006).

Tourism means the time people spends outside their usual environment and it covers the activities visitor participates during the trip and tourists can be either international or domestic travelers (Glaesser et al. 2017). Tourism destination is also defined by UNWTO as a physical space with or without administrative boundaries in which visitors can spend an overnight. Tourism destination is a cluster of products, services, activities, and experiences along the tourism value chain and is kept as a basic unit of analysis of tourism. It is also abstract with its image and identity, which may influence its market competitiveness (UNWTO 2019).

Tourism doesn´t only mean leisure travels, but also business-related travel and travel with aims to visit friends and relatives (Glaesser et al. 2017). In 2015, out of all arrivals globally, half were leisure travelers, 14 % business and professional travelers, 27 % traveled to visit friends and family (VFR) and 6 % was not specified (UNWTO 2016)

Attitudes towards travel health

International travel can expose travelers to numerous risks to health (Leggat & Franklin 2013). An increase in travel-associated importations of diseases was first noted in 1933 when air travel was starting to take place in the ways of traveling (Morens et al. 2004). With bringing people in contact with infectious diseases, travel is an important element and the modern travel and transportation create an increasing threat of spreading different infectious diseases (Morens et all 2004, Aro et al. 2009:68). It has been studied, that the probability of illness increases with the duration of travel (Siikamäki et al. 2015; Leder et al.2003). This provides a challenge not only for health care systems but also for markets such as tourism and transportation of goods (Aro et al. 2009).

The amount of studies related to risk perceptions or knowledge about the dengue burden among cross-continental travelers is relatively low. However, there are a number of studies about travel-related risk perceptions to infectious diseases in general, focusing on travelers´ knowledge, attitudes, and practices (KAP). Therefore, through these studies, some kind of overall picture of risk perceptions about infectious diseases can be gained.

Although the destination of travel and the activities have a significant effect on the risk of contracting a travel-related infectious disease, also the travelers´ personal risk profile has an impact on it. Sridhar et al. (2016) conducted a systematic review of methodologies for measuring travelers´ risk. The conclusion in this study was that there is an overall lack of knowledge of most frequent travel-associated infections and preventative measures demonstrating the need for further health education among travelers. Moreover, Sridhar et al. 2016 encourage the use of multivariate statistical analysis to minimize the errors caused by social pressure and unrealistic optimism and to gain reliable knowledge.

One comprehensive study about European travelers was made in 2004 by Herck et al. Their study discussed knowledge, attitudes, and practices among European travelers in travel-related infectious diseases. It was found out that tourists seek health advice for traveling more than those who are visiting friends and relatives. When asked about malaria risk on their destination, over two-thirds of people traveling to high risk- areas correctly identified the risk. Among people who traveled to no-risk destinations, almost half were unnecessarily worried about the risk of acquiring malaria. The intentions of preventing mosquito bites were quite high among those who participate into this study, up to 78,2% of travelers intended to apply mosquito repellent and almost as many to cover their arms and legs. Half intended to use an air conditioner and sleep under the mosquito net, while up to 58 % intended to use insecticides every night (Herck et al. 2004). However, in a study conducted by Hasler et al. (2019) it was found out that even though most travelers intended to use the repellent, only 2.5 % of travelers recruited to the study applied the right amount of it. Women and people older than 40 years were the most active in this regard (Hasler et al. 2019:30). People who seek health advice before traveling have been shown to have a higher awareness of mosquito-borne diseases and are more willing to use protective measures (Cherry et al. 2016).

Another study conducted by Lalani et al. (2016) compared travelers arriving at malaria-endemic destinations and dengue-endemic destinations. Within their study, all participants had received some pre-travel advice regarding these diseases before traveling. They discovered that the travelers arriving to dengue-endemic destinations used more effective repellents on skin and more frequently on daytime than in malaria-endemic destinations highlighting the importance of pre-travel advice. It was also found out, that the willingness to use protective measures was associated with the female gender, being aware of mosquitoes during the travel and traveling during the rainy season (Lalani et al. 2016:4).

In general, if the travelers do not seek pre-travel advice they either think that they already know everything there is to know, there is no risk related to their travel or they are too busy to do so (van Genderen et al. 2012:6, Dahlgren et al. 2006:1076, Herck et al. 2004). Nonetheless, if travelers do seek advice before their travel, the most popular places to get pre-travel advice according to both Dahlgren et al. and Herck et al. are general practitioners or family physicians, the second most popular are friends and family followed by the internet. However, these studies are done at the beginning of the 21st century, so the use of internets role as a source of pre-travel advice has most likely changed.

In order to define the different risk groups of travelers and their general ways to travel and seek pre-travel advice, the definitions of these groups must be set. This is a good way to consider travelers in crude groups separated from each other by general characteristics such as age and the main reason to travel. This is done in some of the studies mentioned earlier, and a good example is from the study conducted by van Genderen et al. (2012). According to them, travelers over 60 years can be identified as elderly travelers, those traveling alone as solo travelers, business travelers as people whose main purpose was to travel was work-related and travelers visiting their friends and relatives can be considered as VFRs. Last-minute travelers can be defined as travelers who did not seek pre-travel advice or did it only just before the departure (van Genderen et al 2012:2). In general, the latest group is at the biggest risk of acquiring an infectious disease, such as malaria, since last-minute booking and taking no time to seek pre-travel advice increase the risk for contracting the infection (van Genderen et al. 2012:9-10). Odolini et al. (2011) also distinguish risk travelers, and state that travelers who do not pre-book their accommodations in advance encounter more risks than travelers who do (Odolini et al. 2011: 469).

Dengue in European travelers

During the recent decades, the imported dengue to non-endemic regions has increased steadily (Wilder-Smith et al. 2014). Associated with travel, dengue fever is globally one of the most common infections and many dengue-endemic countries are popular tourist destinations (Polwiang 2016:399, Chen & Wilson 2010). In Europe it was the second most frequent cause of fever among the ill returning travelers in 2009 and the study conducted among European travelers 2008–2012 showed a significant increase in proportionate morbidity with dengue (Schlagenhauf et al. 2015, Odolini et al. 2012). The peaks in dengue infections among European travelers, in general, have seen to reflect the dengue-endemicity in oversea departments of different European countries (Schlagenhauf et al. 2015).

The severe dengue infections (DHF, DSS) are rare among travelers and only a few severe dengue cases have been reported (Lumio 2018, Weihcmann & Jelinek 2003). Risk factors for contracting dengue infection include such as the duration of the stay, the time of arrival as well as the dengue-endemicity of the destination (Polwiang 2016:399, Wilder-Smith 2012). The knowledge and attitudes towards preventative measures are highlighted in the prevention of dengue infections since the single most effective preventive measure for travelers is to avoid mosquito bites. Also, the pre-travel advice plays an important role and it should include the risk factors.

A significant amount of travel-related cases of dengue, as with all dengue patients, are asymptomatic or only with mild symptoms. However, if symptoms do develop, they might be misdiagnosed due to the non-specific nature of dengue, the laboratory diagnosis might be unavailable or the diagnosis might be falsely negative due to cross-reaction between other flaviviruses such as Japanese encephalitis (Wilder-Smith 2013:30, Olivero et al. 2016:1134). Thus, the reported number of cases among travelers might be only a fraction of the actual cases.

There are several reports describing dengue infections among European travelers, but only a small share of studies focusing on the backgrounds and the main reasons for acquiring the infections. Already the studies from the 1990s´ state that countries were the infections have been acquired among European travelers are mostly Asian countries, especially Southeast and South Central Asia. Thailand is standing out as an individual country mentioned, but also Indonesia is frequently mentioned. Less often the infection origins from Central America or the Caribbean, but these regions are also represented in these studies (Jelinek et al. 2002, Jelinek et al. 1997, Jänisch et al.1997, Eisenhut et al. 1999). During 1999–2000 the proportion of patients acquiring the infection from Southeast Asia also increased significantly (Jelinek et al. 2002).

Moreover, In 2017 the total number of 2 026 cases were reported through the European Surveillance System (TESSy) returning from dengue-endemic areas. The most frequently reported countries of origin were India, Thailand, Indonesia, and Sri Lanka continuing highlighting the role of Southeast Asian countries. Travelers had mainly traveled for tourism with only a small share traveling for work or to visit friends and family (ECDC 2019b, Verschueren et al. 2015:869, Trojánek 2015:34, Cobelens et al. 2002:333). It has been studied that Thailand is one of the most popular tourist destinations with high dengue endemicity and therefore the risk of acquiring the dengue infection in Thailand is relatively high. It has throughout the studies been leading the statistics as a country with the biggest absolute number of infections acquired (i.a. Polwiang 2016:399, Neumayr et al. 2016:2, Vinner et al. 2011). Especially high transmission rates can be seen during the rainy season from April to December (IAMAT 2019). Another highly endemic traveler destination is Bali Island in Indonesia, with multiple serotypes of dengue circulation and classified having a continuous risk of dengue infection (Masyeni et al. 2018). The peak season for infections among European travelers have been reported to be from July to September (Verschueren et al. 2015, Riddell & Babiker 2017).

Apart from most popular touristic destinations, the large outbreaks around the world have also an effect on the risk of traveler to acquire the infection. Also, the risk of introducing the dengue into the EU areas receptive to the disease is higher during the time of large outbreaks. The large epidemics in oversea-departments of European countries reflect the infections among European travelers; a good example of this kind of large outbreak is the dengue outbreak in La Réunion from 2018 onwards. The island is an overseas department and region of France located near Mauritius and therefore is in favor of French tourists. By June 2019 total of forty percent of over one hundred dengue infections imported to France were acquired from Réunion compared to the whole year of 2017, when only 4 infections were imported from Réunion to France (ECDC 2019b).

Aside from the public health burden that the imported dengue infections have as those cases returning home from dengue-endemic regions, these imported cases also create another risk for both the health and the environment. Returning travelers can transmit the disease to local mosquito populations and therefore increase the risk of local outbreaks in Europe (Polwiang 2016:399). In 2010 over 5.8 million airline travelers arrived in Europe from dengue-endemic areas, from which 700 000 travelers arrived at 36 airports in Europe that locate in the areas where *Aedes albopictus* have been established (Semenza et al. 2014). This highlights the importance of surveillance of dengue, the co-operation between different authorities and the scientific research of importation patterns.

Finnish travelers

Finns travel frequently to both far and near located destinations, and during the past years, the adventure and more casual trips without specific plans have increased (Kainulainen & Pekkanen 2018). Finnish leisure trips abroad have been steadily increasing over the past decade. According to the Official Statistics of Finland in 2007 Finns made around 5 million leisure trips abroad and in 2018 the number was 8.2 million with 6.4 million overnight stays (OSF 2019a, OSF 2007). During the past ten years, the number of overnight stays abroad has increased by 77 % (OSF 2018:11).

The overall number of trips made to distant destinations have increased, but within these destinations, only Asian country standing out is Thailand with 130 000 trips in 2018. Other Asian countries standing out from the statistics are the United Arab Emirates, Vietnam, India and Sri Lanka (OSF 2019a:21). In 2018 the total number of trips made to Asia was 390 000.

From age groups, the group aged between 25–34 is the most abundant group traveling with over 1.2 million trips abroad with overnight stay made in 2018 (OSF 2019a). The behavior and risk perceptions towards health risks are somewhat infrequently studied among Finnish travelers but it is known that risk perceptions, in general, reflect a broader set of affecting beliefs than true estimations of the likelihood of an event (Rothman & Kiviniemi 1999).

Aro et al. (2009) conducted a study about travel-related risks and willingness to take them among Finnish tourists. They found out that willingness to take health-related risks was higher among those under 40 years and on holiday than those who were older and on business trips. Moreover, people who were visiting relatives and people on business trips had different perceptions and took different health-related risks. On holidays, people were found out to have an attitude of "letting go" which was seen increasing the risk of acquiring infectious diseases such as HIV and food-borne diseases (Aro et al. 2009). Trust in fate, or even in god, was related to willingness to take health-related risks. On holidays people want to relax and are ready to loosen control in environments that are not part of their everyday life.

Aro et al. found out that preplanned holidays possessed even a bigger risk towards health risks than unplanned holidays since the cancellations were not considered as an option even in case of known health risks. This was due to the payment of the holiday that had usually been already done before (Aro et al. 2009). This is in contradiction with the usual idea of risk and risk travelers. Odolini et al. (2011) identified a risk traveler as a traveler who encounters a substantial number of risks by not pre-booking all or most of accommodations. This identification also includes the use of accommodation specific for budget travelers or staying in the house of a local resident (Odolini et al. 2011: 469).

A study conducted by Siikamäki et al. 2015 found out that there is a clearly a bigger number of infections than other health problems during travel among Finnish travelers. The probability of contracting an infectious disease increases with the duration of travel and the further the destination, the longer the stay usually is (Siikamäki et al. 2015: 10). However, when the deaths abroad were studied, injuries (26.7%) are evidently the more common causes of deaths than infectious diseases (1.3%) (Lunetta 2009:162). There are significant differences in the main risks between different geographical regions (Siikamäki et al. 2015). The continents with the highest amount of infections among Finnish tourists are Africa and Asia, however, it has been stated that the actual need for medical care might be as much as six times higher than the data available indicates (Siikamäki et al. 2015:10).

DATA AND METHODS

National Infectious Diseases Register

The data used in this study is based on the Finnish National Infectious Disease Register (NIDR). From this register, the data regarding the infections among the Finnish travelers was obtained and based on this information the questionnaires were sent. The National Infectious Disease Register was established in Finland in 1995 and is maintained by the Finnish Institute for Health and Welfare (THL). HUSLAB is the national reference laboratory where the samples are confirmed. Dengue is notifiable in Finland according to the Communicable Disease Act and Decree and dengue infections have been reported from 1999 onwards.

According to Nuorti et al. 2011, the information in this register is used daily to outbreak investigation and to evaluate the incidence of different infectious diseases. In addition, it is important to use this register for scientific research that aims to prevent and control infectious diseases in Finland (Nuorti et al. 2011: 283).

Study population

The study population in this study consists of all the Finns who have been diagnosed with dengue infection from January 2016 to May 6th, 2019. However, to study the descriptive characteristics more specifically, the data for a longer period of 1999–2019 was obtained from NIDR. This data consisted of a total of 701 cases and is only shortly addressed in the beginning of the results-chapter to form a frame for dengue infections among Finnish travelers over the time when dengue has been a notifiable disease in Finland.

Until the 6th of May 2019, there have been altogether 188 dengue infections from January 2016. However, for seven cases, the address was either not found or it was incomplete, thus they were excluded. The official study population was compounded therefore of 181 people. Since the project is executed from May 2019 onwards, the data from 2019 was taken from January to May, and thus the whole year is not considered. The first aim was to study only the years 2017–2019, but due to low number of cases also the year 2016 was included. Earlier years were also considered but as a result of a long time, it was noted that the error and bias are increasing the further went back in time.

With the first round of questionnaires, there was a total of 87 answers (48 %). To increase the percent of the answers, the people who had not yet answered were sent a questionnaire again and reminded to participate in the survey. Eventually a total number of 111 participated in the survey and the final response rate was 61.3 % which is the sample used in the analysis.

Questionnaire

The survey was executed retrospectively with a questionnaire (annex 1). In this case, the travelers with acquired infections during years 2016–2019 were sent a questionnaire. The advantage with sending questionnaires through post, such as this case, is that they reach geographically large area quite equally (Valli 2018:81). However, the weakness of sent questionnaires is usually the low percentage of answers as without personal contact the connection between the participant and the researcher remains weak and it is somewhat easy to ignore (Valli 2018). This weakness has been taken into consideration throughout the process from writing the cover letter to sending the reminder-questionnaires to participants.

Before creating the questions to this questionnaire, the research problems and questions were decided and set. Based on these the questionnaire was carefully constructed to bring in the right information. The form and shape of the questions is the factor which brings most error to the survey, and if questions are understood poorly or differently that it has meant to, the results may become distorted (Valli 2018:78). In addition, Valli states that the language used in the questionnaire is an important factor as well on the understanding the questions (Valli 2018:80). Valli (2018) also states that the time taken to answer the questionnaire should be around a maximum of 15 minutes (Valli 2018:81, Valli 2015). All these factors were considered when piloting the questionnaire and the participants were asked to take time while they filled out the questionnaire. Webropol-questionnaire was also created to lower the threshold of answering to the questionnaire.

The questionnaires were sent through the post in paper with an envelope for returning the filled questionnaire. The Webropol-option was mentioned clearly in both the cover letter and the questionnaire and by doing this, people were encouraged to answer through the web-based questionnaire. To make it easier for the participants to find the Webropol-questionnaire, an individual page was created for it on the official web page of the Finnish Institute for Health and Welfare (THL). In this way it was possible to give the link in a readable form instead of a random Webropol form so the threshold to use the link would be lower.

The questionnaire composed a total of 28 questions and was divided into four different categories: the basic information about the travel, the nature of the travel, protective measures and the background information.

The basic information about the travel included four questions about where the travel took place, how long it lasted and what was the probable location of acquiring the infection. The second section focused on finding out the type of travel and the traveler as well as the activities the traveler has engaged during the trip with eight questions. It was also asked in what type of accommodation did the traveler use and how much did he/she plan about it beforehand. The third section consisted of eight questions and was focusing on the protective measures against mosquito bites. These questions were seeking answer of how much the traveler had information before the trip, where he/she got that information, which actions were taken in order to prevent the mosquito bites and on what time of the day.

The background information was asked with seven questions. The general socio-demographic variables were asked, such as sex, age, education, occupation, and nationality. In this section, the average travel frequency and the usual type of travel were also asked. Lastly, there was an opportunity to clarify answers if needed with an open space.

Both the questionnaire and the cover letter in Finnish were piloted by altogether 10 individuals representing different groups of people by sex, age and occupation. These individuals were asked to read the cover letter and to fill out the questionnaire paying attention to unambiguousness and clarity of questions as well as the possible technical issues related to Webropol questionnaire. Comments about the grammar and overall language were also asked during piloting. Based on these comments the questionnaire and cover letter were modified by some parts to be more understandable. After these modifications, both the cover letter and the questionnaire were sent to the professional translator to be translated also in Swedish. The answered questionnaires received in the paper were entered into Webropol by the researcher from where the report of results was obtained for further analysis.

Travel data

The travel statistics collected by the World Tourism Organization were used in analyzing the attack rate for Finnish travelers traveling to specific countries. The data has been earlier used in international studies focusing on health-related issues, such as malaria and dengue (Rocklöv et al. 2014, Greenwood et al. 2008, Leder at al. 2004). It has been collected from 1995 onwards and the latest year available is 2017. Thus, the attack rates were calculated based on the mean number of 2016–2017 travel data. These statistics are based on the information obtained from the data supplied by each of the destination countries (UNWTO 2018:211). Countries collect this data in different ways and therefore UNWTO guides to using the statistics in relative terms instead of absolute terms (UNWTO 2018:211).

UNWTO outbound tourism data has been calculated based on arrivals data in destination countries (UNWTO 2018). Part of the countries reporting the tourism data have facilitated the arrivals data by country of origin by counting the number of arrivals either by nationality or country of residence. However, not all countries report the data in this regard and some countries only register the data from the most significant countries with the biggest amounts of arrivals or use aggregated categories (UNWTO 2018:211). In addition, some of the countries report the number of arrivals by the data based on the stays in hotels or all accommodation establishments. Hence, the data do not correspond to the actual number of departures from the country of reference, but it provides the best possible estimation about the number of Finnish tourists arriving in specific countries and is therefore used in calculating the crude attack rates for Finnish travelers.

Crude attack rates

As for indicators for analytical epidemiology, crude attack rates for dengue infections among Finnish travelers were calculated. The attack rate is an epidemiological concept, which describes the probability of an outcome in people who encounter the risk during the research period. In this study, the attack rates have been calculated for the study period of January 2016–May 2019. These calculations have been made based on the answers to the questionnaire. In addition, the information about the country where the infections was acquired was reported to NIDR in some cases of the non-responders as well. Thus, there were a total of 135 (71.8%) cases from the study period that had the information of places of exposure and the calculations for crude attack rates as well as the spatial analysis itself were conducted based on this data.

Attack Rate (AR) is the proportion of the exposed population that becomes clinically ill (Talley et al. 2007:93). It is calculated by dividing the number of people at risk who develop a certain illness by the total number of people at risk. In this study, the ARs are calculated per 100,000 population by the cumulative incidence in the unexposed group (Uhari & Nieminen 2012: 21). With final results, the mean of a number of travelers studied and the mean number of infections according have been used to gain the best possible estimation.

$$\frac{\mathit{Infections\ acquired}}{\mathit{Travelers\ arriving}}\ x\ 100\ 000$$

Statistical analysis

In this study, all of the statistical analysis was performed by using R 3.6.0 software.

Descriptive statistics

Demographic variables such as sex, age, and nationality were analyzed with frequencies and proportions to describe the data. Frequencies and percentages for demographic variables were calculated for all of the dengue cases from the NIDR during 1999–May 2019 (N=701) and for the actual sample from the study period January 2016–May 2019

(N=111) to form a comprehensive picture. Furthermore, for the actual sample used in the further analysis (N=111) the frequencies and proportions were calculated for each question from the questionnaire.

T-test

Since the response rate was 61.3 % it needed testing if the sample was representative of all of the dengue cases diagnosed from 2016 to May 2019. T-test is generally recommended to use in testing if two samples are statistical different from each other based on means of each sample (Ruxton 2006). Therefore, T-test was chosen for this analysis to find out, if the mean number of age is statistically different between the original sample and the sample of responders. If the samples are significantly different, it might effect on results. Before performing T-test, the right t-test has to be chosen based on characteristics of the two samples (Ruxton 2006, Neuhauser 2002). The following procedure is widely accepted, and thus it was used also in this study to decide on the right statistical method: 1) If samples are normally distributed, the t-test is used. 2) If samples are not normally distributed, then a non-parametric test is recommended. 3) If samples are normally distributed, but with unequal variances, the Welch t-test can be used.

Thus, the normality of age distribution needs to be tested to find out if the samples are suitable for T-test. The normality was tested with the Kolmogorov-Smirnoff test and it was found out, that the age of all cases during January 2016–May 2019 was about normally distributed with a p-value of 0.17. Also, the age of the sample was normally distributed with a p-value of 0.7 and it was concluded that both groups were on this part applicable for the T-test. However, it was found out that variances between these two samples were not equal. Based on these two results, Welch two sample t-test was chosen. T-test was performed to investigate whether the age of responders and non-responders was significantly different. The observed p-value was ~0.009 supporting the H1-hypothesis that these groups are significantly different (annex 2). This has been considered in the results and limitations.

Regression model

Regression analysis was performed for the sample of 111 participants with binary logistic regression analysis. Like all regression analyses, the logistic regression is a predictive analysis and it is used to describe data and to explain the relationship between either one dependent binary variable, or one or more independent variables. In this study, a binary logistic regression model was fitted into two different models to distinct the statistically relevant factors associated firstly in risk perception about dengue and secondly in taking protective measures.

Multivariate analysis has been recommended to use in the studies of attitudes towards travel-related health risks (Sridhar et al. 2016) and binary logistic regression has been used in the similar studies before (e.g. Hussein et al. 2019, Lalani et al. 2016). Thus, logistic regression was considered as the appropriate regression analysis to conduct as the dependent variables were in both cases dichotomous (binary) with yes/no outcomes. In this analysis the glm2-package for R was used to fit the two models. Both models were adjusted for sex, frequency to travel, pre-travel advice, travel season, education and age. In addition, the second model for the use of protective measures, also risk perception and awareness of mosquitoes and the mosquito bites were included (annex 4). Further on, the fitness of these models was tested with analyzing the residuals by plotting them and checking if they were normally distributed. Both models were found to be fit and thus the results from these models reliable.

Spatial analysis

Spatial analysis, in general, allows us to solve complex problems and better understand what is happening in the world and where. In this study, the visualization of the data is done by using QGIS software version 3.4.8 MADEIRA with GRASS 7.6.1. With spatial analysis, the actual sample size of 111 responders could be completed with information from NIDR, and the sample size used with mapping is 135. This same number has been used in analyzing both absolute numbers of infections and the risk with crude attack rates.

Maps have been used throughout the history to display the geographic patterns of diseases (Pickle & Carr 2010: Koch 2005). However, different problems can be recognized in mapping of health-related data. According to Miranda et al. (2006) three main problems can be distinguished: The existence and the availability of the data, the adequate knowledge of spatial statistics and the sensitivity of health data. With spatial visualization, the preservation of confidentiality and the anonymity need to be assured and individuals have to remain un-identified. With this study, the anonymity was applied to the mapping, as responders were asked to distinguish the place where they acquired the infection abroad. Thus their home address or other personal identifier did not cause problems with analyzing or displaying the areas where the infections were acquired. According to answers of the most accurate place where the infection have been most likely contracted, these places have been added to the map as coordinated points as accurately as possible. Furthermore, based on these points, the clusters of infections were identified globally and locally and further examined both spatially and temporally. Cluster detection is widely used in analysis of disease surveillance and control in order to define scale, identify transmission mechanisms and areas with vectors presence as well as regional differences (Stevens & Pfeiffer 2015:16, Sinkala et al. 2014, Kelen et al. 2012).

Albeit the results of the places of infection got from the responders are significantly more detailed than NIDR has and within international studies focused on the same topic (e.g. Trojánek et al. 2016, Rocklöv et al.2014, Gobelens er al. 2002), the accuracy of provided information does not allow more focused analysis than on a district-level. If the responders would have been able to provide specific addresses of where the infections were acquired, it might have been possible to identify more detailed reasons for detected clusters. However, due to the general nature of dengue, it is in most cases impossible to indicate exactly where the infection has been acquired.

Although spatial analysis with absolute numbers is useful for cluster detections and identifying areas with high disease burden, it is also relevant to know the differences in risks (Pickle & Carr 2010: 144). This means mapping with rates instead of counts. Thus, the attack rates within most popular destinations have also been calculated and further visualized with a choropleth map in this study. From this analysis, the UNWTO travel data to each destination countries was used as a divisor to provide the risk number in relation to Finnish travelers arriving to these destinations.

Though the GIS-based spatial analysis itself is quite simple in this study, it forms the base for this study and provides valuable information on the clusters of acquired dengue infections among Finnish tourists in space and time. Moreover, this information can be compared to the knowledge of highly-endemic areas and the intensity of infections in these regions. Furthermore, information that carefully constructed maps provide for public health is essential when justifying how preventive measures should be targeted.

RESULTS

Demographic characteristics

General characteristics 1999–2019

The data obtained from the National Infectious Diseases Register (NIDR) reveals that the first infections have been diagnosed and reported in Finland in 1999. However, until 2004 dengue has not belonged to the group of diseases that must be reported to the NIDR.

From 2004 the infections among Finns have been steadily raised until 2012, with the highest peak of a total of 90 cases a year (figure 2). Since 2012 the number of infections has been on a relatively higher level than compared to the time before 2012, but the highest number of cases has not surpassed more than 66 infections a year in 2016.

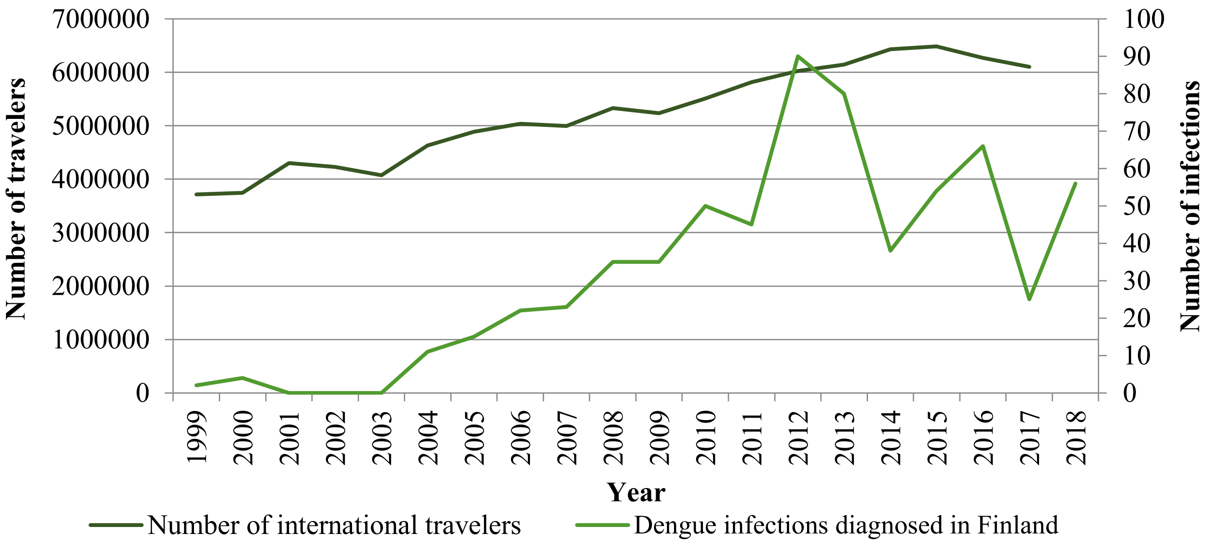

Figure 2. Number of international travelers and number of dengue infections diagnosed in Finland 1999–2019

The demographic characteristics of all dengue cases are presented in table 1. The total number of dengue infections diagnosed until May 2019 in Finland is 701, from which males have acquired slightly more infections (55.6 %) than females (44.4 %). Out of nationalities reported most of the infections were acquired by Finns (91.3 %) and only 6.3 % of infections that have been diagnosed in Finland were diagnosed among other nationalities.

The age of the patients ranges from 1 to 80 years. Among different age groups, the group acquiring most infections has been 26–35 with 29.7 % of diagnosed cases followed by the group aged 35–45 with 141 (20.1 %) cases. The least amount of infections has been diagnosed amongst the age group under 18 years old with only 4.0 % out of all diagnoses.

The time of the year when Finnish travelers have been diagnosed with dengue infections most frequently are winter and early spring from January until April. January is the month with the highest proportions of diagnoses with 14.4 % of all cases followed by March. The least amount of infections have been reported from September (3.7 %) and August (4.3 %).

Table 1. Demographic characteristics of all dengue cases reported to NIDR, 1999-2016

Characteristics	*n*= 701 *n* (%)
Gender	
Male	390 (55.6)
Female	311 (44.4)
Natinality	
Finnish	640 (91.3)
Other	44 (6.3)
Age group	
<18	28 (4.0)
18-25	103 (14.7)
26-35	208 (29.7)
36-45	141 (20.1)
46-55	120 (17.1)
56-65	70 (10.0)
65<	31 (4.4)
Mean	38.7
Median	36
Range	1-80

Study sample January 2016–May 2019

A total of 188 people had been diagnosed with dengue infection between January 2016–May 2019 (Table 2). In 2016 there was a total number of 66 dengue cases diagnosed, in

2017 the number was 25 and 56 in 2018. Until the 6th of May in 2019, the number of diagnosed dengue cases was 50.

The demographics of the participants are presented in Table 2 and 3. Out of all responders, 55 (50.0 %) were female and 53 (48.2 %) were male. The rest 2 (1.8 %) didn't specify gender. Almost all, 109 (98.2 %) of the responders were Finnish by nationality and only 2 (1.8 %) other than Finnish.

The mean age of participants was 40.2 years with a median of 39. The youngest participant was 5 years old and the oldest 76 years old. The most abundant age group among participants was the group of 36–45 year olds with 27.0 % out of all infections followed by a group of 26–35 with 22.5 % and a group of 46–55 with 18.0 % of infections (table 2). The least infections were diagnosed within the age group of 65< (7.2 %).

Table 2. Demographic characteristics of the Finnish travelers who have acquired dengue infection during January 2016 – May 2019

Characteristic	*n* = 111 *n* (%)
Gender	
Male	53 (48.2)
Female	55 (50.0)
Nationality	
Finnish	109 (98.2)
Other	2 (1.8)
Age group (y)	
<18	9 (8.1)
18-25	9 (8.1)
26-35	25 (22.5)
36-45	30 (27.0)
46-55	20(18.0)
56-65	10 (9.0)
65<	8 (7.2)
Mean	40.2
Median	39
Range	5-76

The distribution between options of the highest level of education was quite even (table 3), with 30.0 % having either vocational training or high school, 28.2 % lower degree (e.g. bachelor´s degree) and 26.4 % the higher degree (e.g. master´s degree) as highest level of education.

When asked about the approximate frequency of traveling, the majority of 56 (50.5 %) participants chose the option of 1–2 times a year followed by 3–4 times a year with 33 (29.7 %). Up to 13.5 % stated that they usually travel more than 5 times a year, and only 6.3 % say that they travel less than once a year. The usual type of trip the responders tend to take is a self-arranged trip (53.2 %) whereas 35.1 % usually take the package trip and 11.7 % travel mostly for work.

Table 3. Demographic characteristics of the Finnish travelers who have acquired dengue infection during January 2016 – May 2019

Characteristic	*n* = 111 *n* (%)
Highest level of education	
No vocational training	13 (11.8)
Vocational training/ High school	33 (30.0)
Lower degree (e.g. bachelor´s degree)	31 (28.2)
Higher degree (e.g. master´s degree)	29 (26.4)
Graduate	4 (3.6)
Frequency of international travel	
Less than once a year	7 (6.3)
1-2 times a year	56 (50.5)
3-4 times a year	33 (29.7)
More than 5 times a year	15 (13.5)
Usual type of the travel	
Package trip	39 (35.1)
Self-arranged	59 (53.2)
Work	13 (11.7)

As an indication of the travel time, the month when the dengue infection was diagnosed, were examined from the National Infectious Diseases Register (figure 3). Among responders, the most popular month for travel seems to be March with 23.8 % of all diagnoses reported. Overall, the winter months were in favor of travelers, and in January 16.2 % of responders were diagnosed followed by February and April both with 15.2 % of all diagnoses. The month with the least diagnoses was August with only 1 diagnose reported followed by September and October both only 2 diagnoses reported. This indicates that the late summer-autumn is least in favor of Finnish travelers in traveling to dengue-endemic destinations. It must be noted, that the actual travel months might slightly differ from these results, since the incubation period for the virus to develop symptoms ranges from 4 to 10 days. Thus the actual travel dates with part of the cases might be within a previous month than reported, but this not affecting significantly to these observations of Finnish travelers acquiring the infections during winter months.

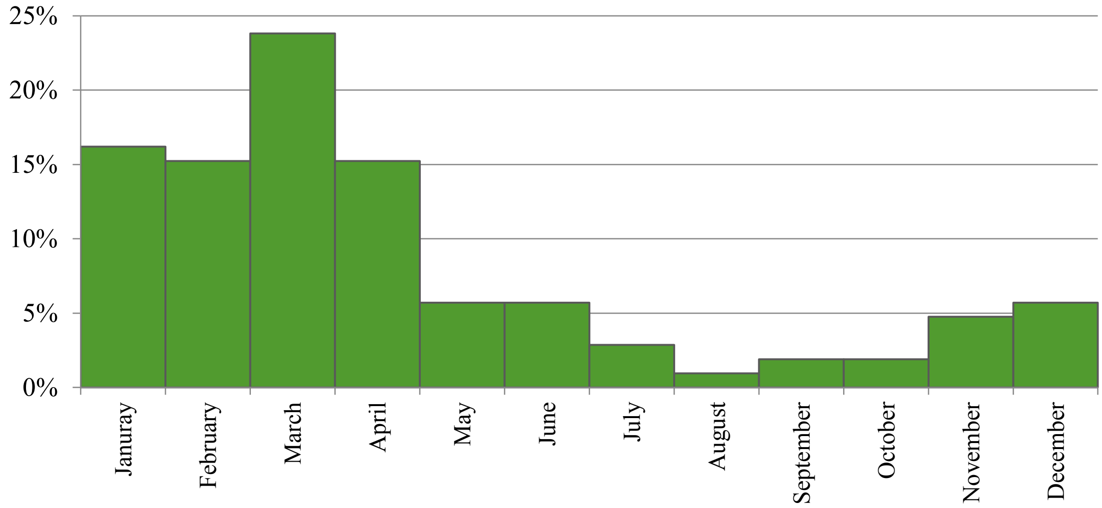

Figure 3. Months of reported infections in National Infectious Diseases Register, January 2016–May 2019

Place of exposure

Out of 111 responders, 110 could specify the country where the dengue infection was most likely acquired. Also, information of places where the infection was acquired was available for 25 additional cases from the NIDR who did not answer to the questionnaire. Therefore, altogether the countries of origin could be identified for a total of 135 cases, which covers 71.8 % of all (N=188) cases from the study period. The proportion of countries of origin per each year from the study period was quite even with the biggest proportion reported from 2018 of 69.6 %. The year 2016 had 65.2 % of origin countries reported and for the years 2017 and 2019 the proportion was 64.0 %.

Geographical areas where the infections have been acquired among Finnish travelers are presented on figure 4. From cases January 2016–May 2019 the vast majority was acquired from Asia (94.1 %) and the rest from the Americas (6.7 %). No other geographical areas came out amongst the answers and thus continents such as Africa and Australia were not presented at all. Out of all the dengue infections acquired from Asia, total of 110 (81.5 %) cases had an origin from Southeast Asia and the majority of 78 (57.8 %) from all cases were acquired from Thailand (figure 4). After Thailand, the second biggest amount of infections originated from Indonesia with a total of 18 cases and 13.3 % proportion of all infections. These two Southeast Asian countries were the only two countries standing out from the data throughout the study period with significantly high numbers of infections acquired.

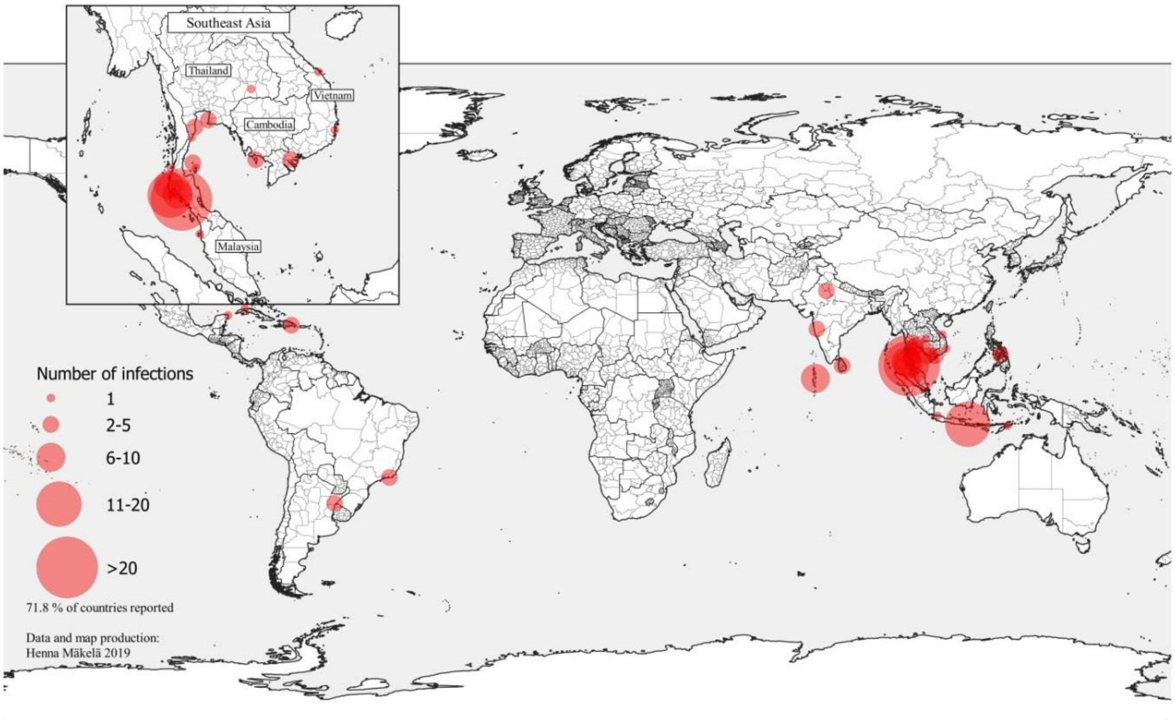

Figure 4. Geographical areas where dengue infections were acquired among Finnish travelers January 2016–May 2019.

As mentioned, Thailand alone covered 57.8% of cases as a country where the infection was most likely acquired. However, when looked more closely within a country, it can be seen that the cases are not evenly distributed across the country and they were clustering mostly around the Northwest coastline of Thailand (figure 5). Island Koh Lanta was the place with the highest number of infections acquired as a single place, and up to 30.8 % of all infections contracted in Thailand during the study period originated there. Koh Lanta was followed by Phuket with a proportion of 21.8 %. Located relatively near to Koh Lanta, Krabi and Khao Lak also stood out in the results both with proportions of 7.7 % from all the infections reported from Thailand. When looked at the infections acquired from Thailand yearly, the year 2018 stands out with a total of 28 cases followed by the year 2019 with 24 cases. As the study period only reaches until the beginning of May 2019, it can be inferred that the total number of dengue infections will most likely exceed the number from 2018. In 2017 only 7 cases were diagnosed to be originating from Thailand

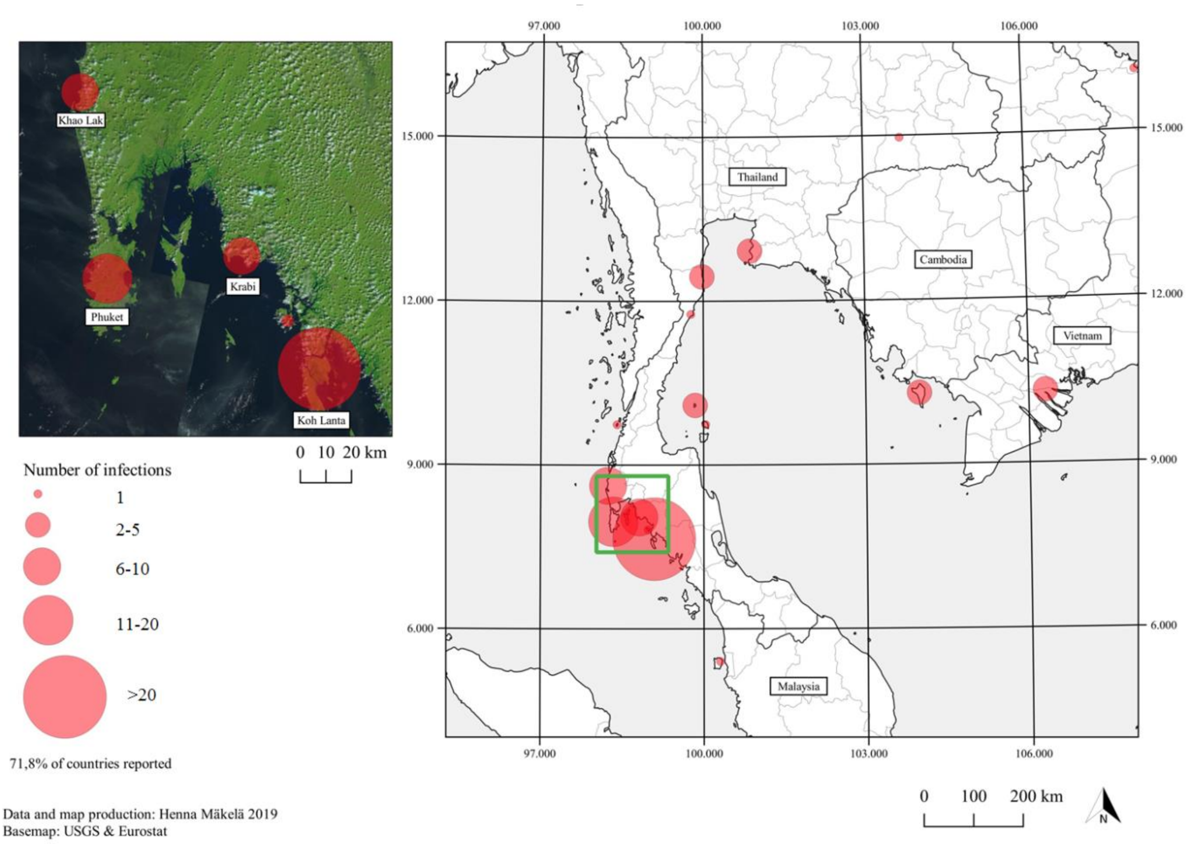

Figure 5. Geographical clustering of dengue infections in Thailand among Finnish travelers, January 2016–May 2019

After Thailand, Indonesia was the second most popular destination with a frequency of imported dengue infections. Total of 18 infections were acquired from Indonesia during the study period. As with Thailand, cases are not evenly distributed across the country. Most of the cases are clustered around the Denpasar area in Southern Bali as well in

Gili-Islands located Southeast of Bali and Northwest of Lombok. Temporally cases are clustering into the year 2016 with 72.2 % (13) out of all reported cases from Indonesia. After 2016 only 6 were reported to be originating from Indonesia, 3 in 2017 and 3 in 2019. In the Maldives only 7 cases were diagnosed, but out of 200 inhabited islands, all cases clustered around Maafusi and Hulhumale islands which are geographically closely located to each other. Temporal clustering couldn´t be seen due to a low number of reported cases. With the rest of the countries reported, neither geographical nor temporal clustering could be seen due to a few reported dengue cases.

Table.4 Destinations where infections were mainly acquired among all cases who had the country of origin reported, 2016–2019

Destination	*n* =135 *n* (%) Number of infections
Asia	
Thailand	78 (57.8)
Koh Lanta	24 (17.8)
Phuket	17 (12.6)
Krabi	6 (4.4)
Khao Lak	6 (4.4)
Indonesia	18 (13.3)
Bali	10 (7.4)
Gili Islands	6 (4.4)
Maldives	7 (5.2)
Vietnam	7 (5.2)
Sri Lanka	5 (3.7)
India	4 (3.0)
Philippines	4 (3.0)
Other	4 (3.0)
America	
Brazil	2 (1.5)
Other	6 (4.4)

Crude attack rates

Crude attack rates were calculated to analyze the risk of dengue infections for Finnish travelers (annex 3). ARs were calculated for the destinations with the most abundant numbers of imported infections. Destinations used in this analysis are based on the answers that participants gave to the questionnaire (N=111) and additional cases who had the existing information of the country of origin in the NIDR and who did not respond to the questionnaire. Therefore the number of cases used in this analysis was the total of 135 out of all 188 cases diagnosed during the study period 2016–2019.

There were only few infections reported outside Asia, and thus all of these destinations used in this analysis are located in Asia. Restrictions caused by the availability of UNWTO travel data are discussed further in the limitations-section.

The most accurate numbers based on the width of 95% confidence intervals are calculated for Thailand and Indonesia (annex 3). Thailand has the highest number of arrivals and per 100,000 travelers there are approximately 13.5 who acquire dengue infection (figure 6). The attack rate is somewhat higher in Indonesia with 20.9 getting ill per 100,000 travelers. Notable is also the attack rate of 55.6 for the Maldives, as the number of arrivals is significantly lower than to Thailand or Indonesia and compared to number of infections, the relative risk is thus higher. In the Philippines the number of travelers getting sick is approximately 15.1 and in Sri Lanka 18.5 per 100,000 travelers.

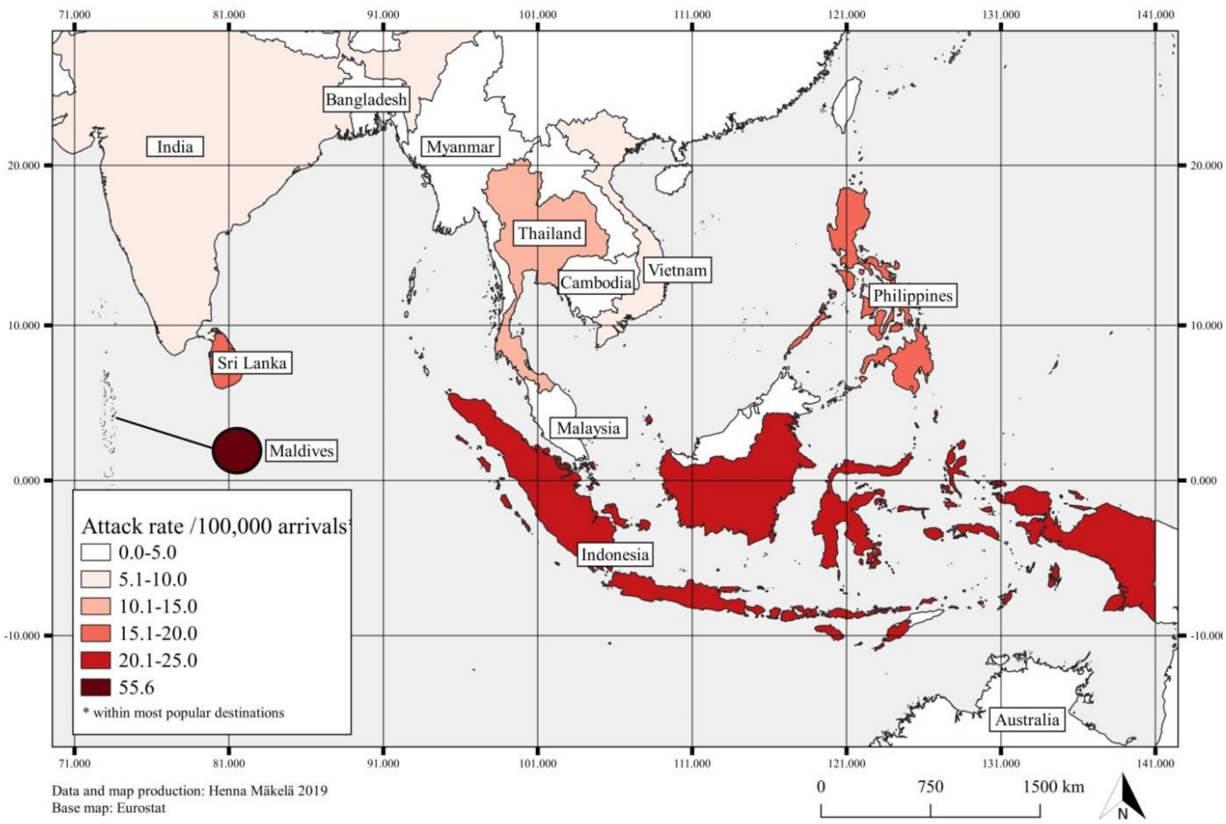

Figure 6. Crude attack rates for dengue in most popular destinations among Finnish travelers, January 2016–May 2019

Type of traveler and the trip

Travel characteristics for the sample (N=111) about duration and type of the trip have been presented on table 5. The participants were asked a total of 8 questions describing the overall nature of the trip and the traveler (annex 1). These questions were concerning the following: 1) The duration of the trip, 2) type of the trip, 3) travel companion 4) the main purpose of the trip, 5) booking of the accommodation, 6) type of accommodation, 7) nature of the trip and 8) and the places time was mostly spent in during the trip. These questions were aiming to answer to the second research question of factors associated with dengue infections and defining the group of Finnish travelers at the risk of dengue.

Most of the travelers spent 14–21 days on their trip (62.2 %) with median days spent on a trip being 14 (figure 7). A total of 42 (37.8 %) out of all 111 responders spent exactly 14 days on their trip, during which they acquired the dengue infection. Only 15 (13.5 %) of the trips took more than 21 days and 27 (24.3 %) less than 14 days. The shortest trip took 7 days and the longest 180 days, with a mean of 21, 5 days.

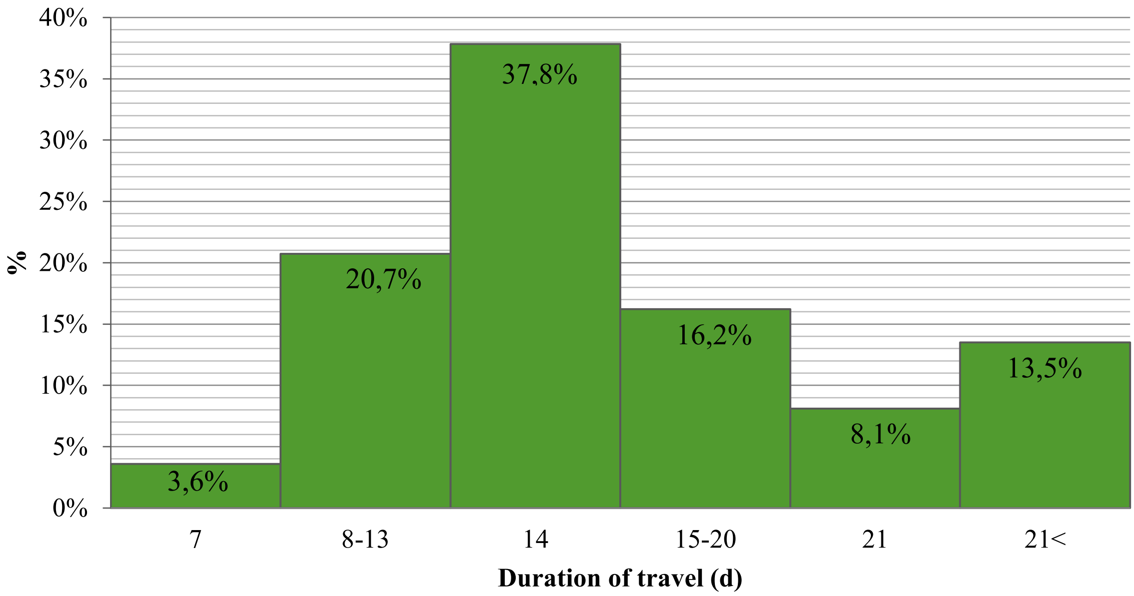

Figure 7. Duration of travel categorized by days spent on a trip, January 2016–May 2019

The majority of the trips were self-arranged (55.0 %) followed by package trips arranged by traveling agencies (37.8 %) (table 5). Only 5.4 % of the trips were made mostly because of work. Almost all (89.1 %) of the responders defined the main purpose of the trip as a holiday and only 2.7 % of responders traveled mostly to visit friends or family. When asked about the travel companion, the majority of travelers answered that they traveled either with spouse or friend (47.7 %). The second most popular option was family (25.2 %) and only 10 (9.0 %) of responders traveled alone.

Table 5. Duration of travel and type of the trip among the responders

Characteristics	*n*=111 *n* (%)
Duration of the trip	
<14	27 (24.3)
14-21	69 (62.2)
21<	15 (13.5)
Median (range)	14 (7-180)
Type of the trip	
Package	42 (37.8)
Self-arranged	61 (55.0)
Work	6 (5.4)
Travel companion	
Alone	10 (9.0)
Friend/spouse	53 (47.7)
Group of friends	11 (9.9)
Family	28 (25.2)
Other	7 (6.3)
Purpose of travel	
Holiday	98 (89.1)
Work	4 (3.6)
Visit friends/family	3 (2.7)
Other	5 (4.5)

The vast majority of 83.8 % had pre-booked their accommodation beforehand of the travel (table 6). Only 2.7 % had booked the accommodation just for the first night and 4.5 % answered that they had booked no accommodation before they arrived at the destination. Hotel was the most popular type of accommodation with the majority of travelers (78.4 %), hostel with only 0.9 % and friends or family with 3.6 %. A total of 18 (16.2 %) responders defined the accommodation as “other” and furthermore defined this meaning mainly either bungalow or rented apartment.

When asked which definition describes trip the best, the most popular answer was "holiday on a beach" with 72 (64.9 %) answers. The second most popular answers were "holiday in the city" and "backpacking" of which each had chosen 12 (10.8 %) of responders. The last question of this section was concerning about the surroundings where the time had been mostly spent during the travel. Again, the majority, up to 70.3 % of responders had chosen the beach as the option best describing their trip. This was followed by the city as the second most popular option (26.1 %) and thirdly by swimming pool (21.6 %). Only 7.2 % of the responders had spent most of their time on the countryside and 5.4 % on a nature hiking on marked routes. Only one participant mentioned that time had been spent mostly hiking in nature, off marked routes.

Table 6. The choice of accommodation and the nature of the trip among the responders

Characteristics	*n*=111 *n* (%)
Pre-booking of acommondation	
All/most	93 (83.8)
Half or less	7 (6.3)
Only for first night	3 (2.7)
None	5 (4.5)
Accommodation	
Hotel	87 (78.4)
Hostel	1 (0.9)
Friend/family	4 (3.6)
Other	18 (16.2)
Nature of the trip	
Holiday in city	12 (10.8)
Holiday on beach	72 (64.9)
Active holiday	6 (5.4)
Backpacking	12 (10.8)
Work	4 (3.6)
Other	8 (7.2)
Time spent mostly in	
City	29 (26.1)
Countryside	8 (7.2)
Beach	78 (70.3)
Swimming pool	24 (21.6)
Nature, on marked routes	6 (5.4)
Nature, off marked routes	1 (0.9)

Risk perceptions, pre-travel advice and protective measures

The responders (N=111) were asked a total of 7 questions related to protective measures: 1) Did they perceive the risk for dengue, 2) did they seek for pre-travel advice, 3) if they did, where they received it and 4) if it was from internet, what where the webpages they received it from. In addition, 5) did they use protective measures and if so, 5) which times of a day and 6) what were the measures used. Last question was 7) if they noticed mosquitoes or mosquito bites during their trip. This section of the questionnaire was aiming to mainly answer to the third research question of the risk perception and the protective measures, but also to the question of factors associated with the dengue risk.

The majority of 67 (60.4 %) were not aware of dengue risk in their travel destination beforehand (figure 8). However, 39 (35.1 %) were aware of the risk and 5 (4.5 %) could not remember if they were aware or not. When asked if participants sought pre-travel advice to prevent mosquito bites, 64.9 % of the responders answered that they had not sought any information beforehand and 29.7 % that they did seek advice (figure 8). When analyzed the factors associated with the risk perception, different variables were fitted into a binary logistic regression model. As a result, only two variables found out to be significant (p value < 0.001) (annex 4). These variables were seeking pre-travel advice and traveling during the rainy season. It was found out, that those traveling during the rainy season were 5.4 times more likely to be aware of the risk than those traveling during the dry season. Those who did seek pre-travel advice were 4 times more likely aware of the risk than those who did not.

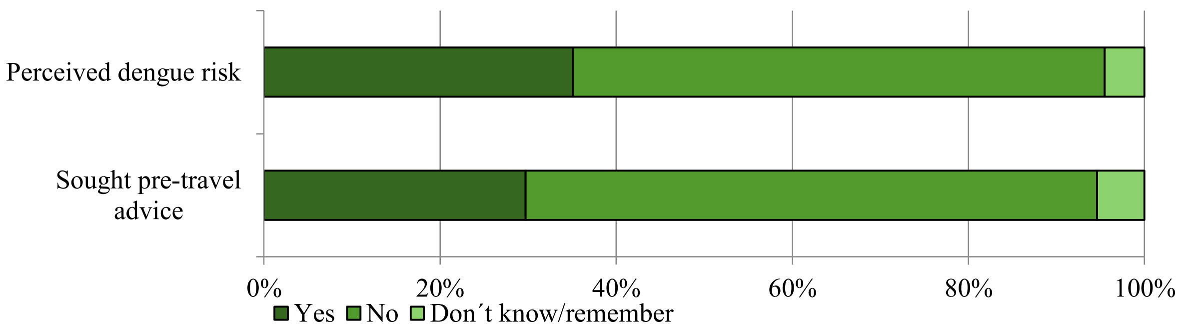

Figure 8. Risk perceptions and pre-travel advice

Among all participants who had sought pre-travel advice, it was asked where the advice was received from. There were a total of 50 answers given to this question, albeit only 33 people had answered that they did seek pre-travel advice. This means that some of the participants have chosen more than one option. Among these 33 answerers the most popular way to receive pre-travel advice was through the internet (81.8 %) (table 7). Most of the responders, who had chosen the internet as the source for pre-travel advice (65.4 %), did not specify from which websites they had found the advice. Among those answers which specified the source of information, Google and Facebook were most popular.

Seeking pre-travel advice from internet was followed by asking advice from friends and family (24.2 %). Only 3 (9.0 %) of these 33 responders sought information and advice from the Finnish Student Healthcare System (FSHS) or other student healthcare system. Only a couple of individuals had sought advice from either occupational health or private doctor. Moreover, a total of 10 individuals (30.3 %) answered that they had sought pre-travel advice through other ways than in given options and defined this meaning mostly their own previous experiences. A couple of individuals defined the resource for the received information meaning pharmacy, local people or the guidance provided by the traveling agency.

Table 7. Pre-travel advice received from among the responders

Characteristics	**n* =33 *n* (%)
Pre-travel advice received from*	
Internet	27 (81.8)
Friends and family	8 (24.2)
FSHS or other student health service	3 (9.0)
Occupational health	1 (3.0)
Private doctor	1 (3.0)
General doctor	0 (0.0)
Other	10 (30.3)

When asked about whether the participants had prevented mosquito bites, a total of 71 (64.0 %) answered that they had taken some preventative measures in order to protect themselves against mosquitoes (table 8). Yet, 39 (35.1 %) said that they had not taken any measures in order to prevent bites. When analyzed the factors associated with taking protective measures, different variables were fitted into a binary logistic regression model. It was found out that only two explanatory variables were significant (P-value <0.01 or 0.001) in relation to whether the traveler used the protective measures or not. These variables were sex and the activity in seeking for pre-travel advice (annex 4). Those who sought pre-travel advice against mosquito bites were 34.9 times more likely to use protective measures than those who did not (P-value < 0.001). Moreover, females were 3.6 times more likely to use protective measures than males (P-value <0.01).

To the question about awareness of both mosquitoes and mosquito bites, biggest share (40.5 %) of responders answered that they had noticed both the mosquitoes and the bite marks (table 8). On the contrary, 18.0 % of responders had noticed neither the mosquitoes nor their bites. Approximately one fifth (21.6 %) had only noticed the bite marks and 16.2 % had only noticed the mosquitoes. Out of al responders 3 (2.7 %) did not remember if they had been aware of either mosquitoes or the bite marks.

Table 8. Prevention and awareness of mosquito bites during the travel among the responders

Characteristics	*n* =111 *n* (%)
Preventing mosquito bites	
Yes	71 (64.0)
No	39 (35.1)
Awareness of mosquitoes/bite marks during the travel	
Did not notice neither mosquitoes nor bite marks	20 (18.0)
Noticed only mosquitoes	18 (16.2)
Noticed only bite marks	24 (21.6)
Noticed both mosquitoes and bite marks	45 (40.5)
Do not remember	3 (2.7)

To find out if the protective measures had been executed on the right time of the day, the participants were asked which hours they protected themselves against mosquito bites (figure 9). The vast majority of responders answered that they had used protective measures either during evenings (48.6 %) or during nights (18.0 %). This was followed by 14 (12.6 %) who stated that they had used protective measures during the afternoon. Only 9 (8.1 %) had protected themselves on mornings, 7 (6.3 %) on forenoons and 6 (5.4 %) during midday. A total of 10.8 % of responders stated that they had used protective measures during all hours of the day and 4.5 % couldn´t remember at what hours they used protection.

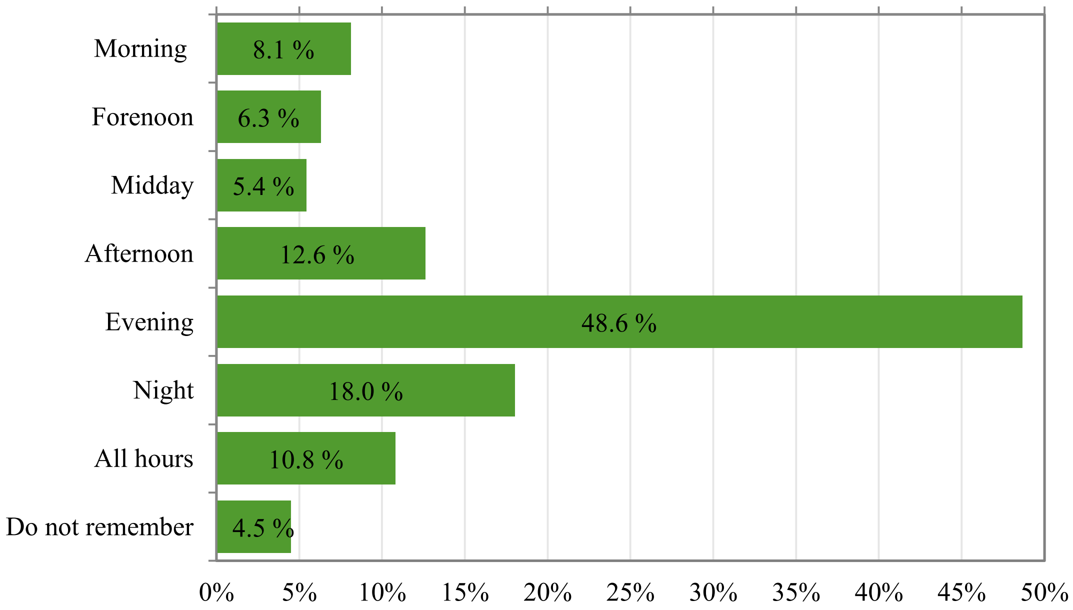

Figure 9. Hours when protective measures were taken among the responders

Finally, the participants were asked how they had prevented mosquitoes from biting (figure 10). It was possible to choose multiple options, and there were a total of 176 answers. A most popular way to prevent mosquito bites was the use of effective repellent on skin with 55.9 % of answers. This was followed by the use of air conditioning during nights with 41.4 % and getting rid of mosquitoes from the bedroom before night with 19.8 % of answers. In addition, 12 (10.8 %) responders stated that they have used mosquito net during nights. Thus 72.0 % of all participants had protected themselves against mosquitoes during the nights. However, since multiple options were possible to select, this doesn´t mean that they had not used any preventive measures during the day.

When it comes to protect oneself from mosquito bites with physical coverage such as clothing, 15.3 % had used long-sleeved clothing and 5.4 % light-colored clothing. A total of 5.4 % had covered their head with a hat and 2.7 % had covered ankles and feet. Thus, 28.8 % of responders had used physical coverage against the bites during the day.

Only 2 (1.8 %) stated that they had used some other measures in prevention against mosquito bites than given options.

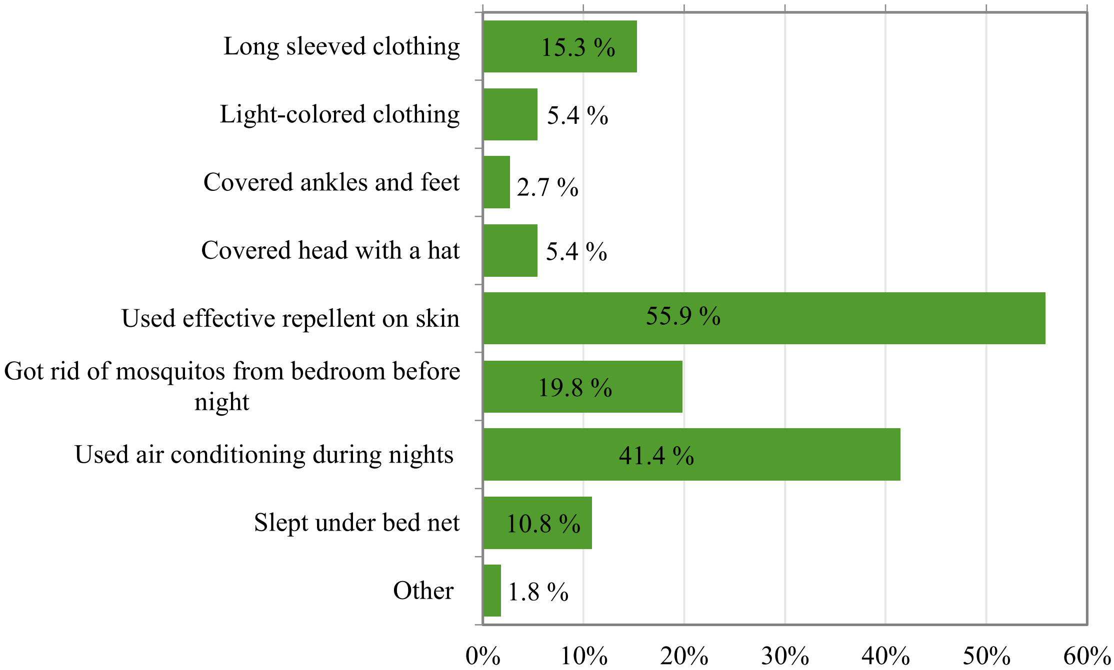

Figure 10. Protective measures taken to prevent mosquito bites

When analyzed further the protective measures and the hours of the day they have been taken, it can be seen that there are differences in ages (annex 5). When it becomes to protective measures used, people who slept under bed net were slightly younger than other groups, based on median ages. The same could be seen among people using protective measures during the morning, forenoon, midday and afternoon (26.5–34). Moreover, people who used light-colored clothing got rid of mosquitoes before night and used protection during evening and nights were slightly older (median 38–44).

At the end of the questionnaire, there was a change to specify the given answers or give additional information. Some of these answers revealed the lack of knowledge of how dengue infection is contracted, by mentioning the possible bacteria entering through a small wound somewhere on a body. Similar uncertainty was regarding the distribution, some of the responders stated that they were unaware of the possibility of dengue distribution in the cities, and thus they did only use preventative measures in jungles or on other more forestry areas. Likewise, the lack of knowledge among healthcare workers was also presented among these answers. A few mentioned that they had sought pre-travel advice, but nobody mentioned dengue risk in the area or that the advice had been for that there is no dengue risk in the cities. A couple of responders mentioned, that they had received comprehensive advice regarding vaccine-preventable diseases and malaria, but no mentions about dengue.

In addition, some of the answers highlighted the lack of knowledge of tropical diseases among healthcare workers in the care of the sick patients. After seeking medical care, a couple of responders mentioned that nobody in the hospital took seriously their suspicions of dengue fever and thus the care was not correct from the beginning. It was also mentioned that there was no information given if it still is safe to travel after acquiring dengue infection. This was also quite frequently asked either on this part of the questioner or by email.

It was frequently mentioned that it was very difficult to notice the biting mosquitoes and that the responder was only aware of one or two mosquitoes during the whole trip. Likewise, it became quite clear out of these answers that participants were not aware of the fact that mosquitoes transmitting diseases are active during the day.

DISCUSSION

Place of exposure

As Wilder-Smith et al. (2014) state, the cases of imported dengue infections to regions where the disease is not endemic has increased throughout the last decade. This applies to Finland as well, and as the number of international travelers has steadily risen, so have the number of dengue infections. The high endemicity of Asia can be seen in this data, where up to 94 % of the infections were acquired from. The crude attack rates were calculated only for Asian destinations and these rates range from 5.2 to 55.6 dengue cases per 100,000 Finnish travelers. Asia has been shown to be one the continents of the highest numbers of travel-related infections in general among Finnish travelers (Siikamäki et al. 2015).

Among Finnish international travelers, the places where the infections have been acquired are mainly popular tourist destinations located in Thailand or Indonesia. The same Asian countries are the ones that can be seen as most frequent countries of origin with dengue infections at the European level as well (Neumayr et al. 2016, Verschueren et al. 2015, Trojánek 2015, Rocklöv et al. 2014, Cobelens et al. 2002). Further on, as Jelinek et al. 2002 state; these numbers most likely mainly reflect the habits of tourists rather than the true variations in disease activity. Especially Thailand has been in the favor of Finnish tourists for years, and it is the only Asian country highlighting from the OFS-statistics. Not only among Finns and other Europeans, Thailand is also in favor of travelers around the world. It is one of the most popular touristic destinations in the world with almost half of the tourists coming from the non-endemic areas (Polwiang 2016). Multiple studies show that Thailand is one of the countries where travelers are most likely to acquire the infection (Schlagenhauf et al. 2015, Wichmann & Jelinek 2003). These factors considering, it is not surprising that Thailand stands out from the data. However, when considering the attack rate calculated for Finns arriving to Thailand, it is the third-lowest from all Asian destinations. Moreover, when compared to a Swedish study conducted by Rocklöv et al. 2014, the attack rate of 13.5 is almost the same as it was for the Swedish travelers traveling to Thailand with 13.6 per 100,000 arrivals. Rocklöv et al. used cases that were reported to health officials as well as the UNWTO travel data, so it is comparable to the results of this study. As Rocklöv et al.

put it, the high absolute number of dengue infections that travelers acquire in Thailand only reflects the preferences in travel for popular destinations, whereas attack rates are a better reflection of the true risk to the traveler (Rocklöv et al. 2014:414). Hence, there is a high volume of travelers traveling to Thailand and thus the absolute number of infections is also high. However, the risk within other destinations is higher even though the absolute number of infections is lower.

Within Thailand, Finnish tourists favor several locations mainly by the coast or on the islands near the coast. Among the travelers who had acquired dengue during the study period, especially the Island of Koh Lanta stood out with high numbers of infections. Moreover, locations near Koh Lanta and within Krabi-region had a higher number of infections compared to other regions in Thailand. As individual places besides Koh Lanta, Krabi, Phuket and Khao Lak were highlighted among responders. From these locations, Krabi and Koh Lanta are located in the Krabi-region whereas Phuket and Khao Lak are different regions, but located next to Krabi. As Polwiang (2016) presents, Krabi-area is the second most endemic- region for dengue within the country with approximately 296 dengue cases in 100,000 population during the rainy season. Also Phuket and Phang Nga- regions are highly endemic areas, Phuket with 214 dengue cases and Phang Nga with 168 in 100,000 population. There wasn´t available information of arrivals to specific destinations within the country and therefore the crude attack rates for individual places could not be calculated.

The second biggest absolute number of infections was imported from Indonesia, and as the annual number of arrivals is significantly lower than in Thailand, the risk of acquiring dengue is higher in Indonesia. Within Indonesia, the most popular touristic destinations were highlighted, as the Island of Bali and the Gili-Islands were mainly the locations where infections were acquired. Indonesia and especially Bali have been represented in other studies as a destination with multiple serotypes circulating (Masyeni et al. 2018). What it comes to Vietnam and the Maldives, the absolute number of infections was the same between these countries, but as analyzed with a number of arrivals, the difference with these destinations can be clearly seen. As there are around 17,000 people yearly arriving in Vietnam the risk of having dengue is significantly lower than in Maldives with only around 3,000 arriving from Finland and the absolute number of 7 infections raising the risk for people getting infected from 100,000 travelers to 55.6. Moreover, Sri Lanka was one of the destinations with a higher risk of dengue infection, also a destination in favor of international tourists. As mentioned earlier, these same countries are highlighted on the European level as well (i.a. Neumayr et al. 2016, Verschueren et al. 2015). The only country standing with lower frequency in infections compared to Europeans is India, as it is not a popular destination among Finns.

Based on these findings it can be concluded, that infections among Finnish travelers reflect mostly the preferences among Finnish travelers, but also at some state the level of dengue endemicity in the destinations. For example, Trojánek et al. and Jelinek et al. came to the same conclusion at both European and country-level. A good example of this is that during the beginning of 2019 biggest numbers in dengue infections globally have been seen in Brazil. However, as Brazil is not in favor of Finnish tourists, the situation within the country can´t be seen among Finnish travelers. On the other hand, as the cases imported from Thailand are clustering into the years of 2018 and 2019 and when compared to ECDC reports of the dengue situation in Southeast Asia, it can be seen that there might be an association since the numbers of arrivals haven´t fluctuated much. As in Thailand, also in the neighboring countries, the numbers of cases have increased dramatically during the past two years (ECDC 2019a). Since there are not near as many Finns traveling to countries such as Cambodia, Laos, and Malaysia, the situation in these countries is not reflected to the number of infections. Anyhow, it could be speculated that maybe the travelers visiting these countries are younger and on a longer trip, and thus are either asymptomatic or diagnosed in destination countries.

According to Polwiang (2016), the factors for acquiring dengue infections include the duration of the stay, time of arrival and the stay in the dengue-endemic regions. In this case, the results indicated something completely different in regard to the second point. Unlike European travelers who acquire the majority of infections during the rainy season from July to September (IAMAT 2019, Riddel & Babiker 2017, Verschueren et al. 2015), this data shows that Finnish travelers acquire most of the infections during the dry season, from January until March. During this period the level of endemicity is significantly lower (Polwiang 2016). It is quite the opposite of what could be expected from the peak periods in Thailand, but it clearly shows the trends in Finnish travel preferences and continues to highlight role that they play in acquiring the infections. Moreover, it highlights the Finnish winter holiday-season when trips to warmer destinations are popular as throughout the year, Finns travel more frequently during June-August (OSF 2019b). If there were no holidays during the winter season in Finland, Finns might be more eager to travel to dengue-endemic destinations during the summer season, as do other Europeans. Thus, infections would be acquired during the rainy season and they would be more abundant. However, it must be noted that rainy season in Indonesia is from November until April, which might have an impact on these results as well.

In addition to destinations, ECDC risk assessment states that dengue epidemics in European countries´ oversea-departments reflect the infections among European travelers, but as Finland doesn´t have any such regions, the trend in infections is more reflected on trends in tourism and the dengue endemicity on these locations.

The type of traveler and the trip

Based on these results, it could be concluded that the group that typically acquires dengue infections among Finnish international travelers is mostly the group of 26–45 year-olds on a self-arranged, pre-booked holiday of 14 days with a hotel stay and time spent mostly at the beach.

According to OSF-statistics, the most abundant group traveling among Finnish travelers is the group of 25–34 year-olds. The age group contracting biggest numbers of dengue infections is the same both during the study period and the whole period of 1999–2019, when dengue has been a notifiable disease in Finland. Thus the situation can be seen to reflect the general trend in traveling in this matter. The second biggest group acquiring infections are 36–45 year-olds and altogether the age group from 26 to 45 has of 53.7 % of all diagnoses done during the past three years.

Even though there can be seen quite a typical trip for Finnish travelers based on these results, most of the trips were self-organized instead of package trips. This reflects the general tendency to travel, as it is constantly getting easier to book your own trip with accommodation through the internet without involving travel agencies. As it has been seen lately in media, traveling agencies are not as profitable anymore and even big companies are facing difficulties (HS 2019). This trend can thus be seen through these results as well. However, in spite of the general trend, still up to 37.8 % of the trips responders took were package trips. Moreover, a clear majority of 89.1 % said that they traveled for holiday and stayed in a hotel (78.4 %). These results endorse the overall picture of the type of trip Finns take to these destinations. Similar results can be seen in studies done among Dutch and Czech travelers with dengue infections, as generally the vast majority travels for tourism and only around 3–4 % of travelers travel for work or to visit friends and family (Trojánek et al. 2016, Cobelens et al. 2002). These findings also support results by Aro et al. (2009) about Finnish travelers which indicated that those under 40 years old and on holiday are willing to take more health-related risks than those over 40 and on a business trip. The attitude of "letting go" that Aro et al. describe can somewhat be interpreted from these results.

In general, the pre-booking of holidays is considered the factor that reduces the risk for the infections of different communicable diseases (Odolini et al.2011, van Genderen et al. 2012). However, based on this study, it can be seen that the vast majority had pre-booked all of the accommodations beforehand and only 4.5 % out of all responders had only booked nothing in prior to arriving at the destination, indicating the opposite from the general idea. A similar perspective is offered through a study conducted by Aro et al. (2009), which states that pre-planned holidays possess bigger threat than unplanned holidays among Finnish travelers. Their results indicated that with pre-booking the accommodations, the payment has been made and thus people will execute their holidays in spite of possible risks that may pop up afterwards. Results from this study with dengue infections could, in theory, be seen to be in line with Aro et al. foundings. However, in this case, the results reflect mainly just the way Finns travel to these destinations and not the risk in pre-booking the accommodations. As the majority of people traveling to these destinations pre-plan their holiday, it can be also seen in dengue infections and not as a factor affecting the risk of infection. It must be noted, that this data only covers dengue infections that have been diagnosed in Finland and thus excludes all the diagnoses done in destination countries. However, if there was a significant difference between patients diagnosed in Finland and patients diagnosed abroad, it will be still unlikely to change the overall picture of how Finns travel to Thailand. As it is not possible to have the information about these travelers diagnosed in destination countries, it must be noted that this data allows us to see the best possible picture of the situation.

When it comes to the risk during travel, the probability of illness in general increases with the duration of travel (Siikamäki et al. 2015; Leder et al. 2003) and according to Polwiang (2016), the main factors for acquiring dengue infections include the duration of the stay. The relative risk for acquiring the infection rises the longer the stay is, and through these results, the duration of the trip that significantly increases the risk for dengue seems to be 14 days. However, as most of the travelers spent 14–21 days on their trip and only a few less than this, it can´t be reliably said, if this reflects the risk for dengue or does it only the way Finns travel. Spending exactly 14 days (2 weeks) abroad could be seen as quite a general way Finnish people travel to distant destinations considering the possible time that people can generally take off from work. The incubation period considered with a range of 3–14 days (Chen & Wilson 2010:440, Siikamäki et all 2003:2055), the duration of 14–21 days could be seen as long enough for people to acquire the infection, but short enough for them to develop the symptoms towards the end of their trip and seek for medical care after returning to Finland.

Through activities and the places where the time has been mostly spent in, the holiday- type of trip continues to be highlighted. Compared to other activities, people spent most of their time on a beach. Relatively few had been backpacking or hiking either on marked on unmarked routes without pre-booking their accommodation, which is generally considered as risk travel. These travelers usually encounter the local community and nature more closely and are therefore in a bigger risk of acquiring infectious diseases (Odolini et al. 2011:469). In this case, the risk group was very different throughout the result with pre-bookings, hotel stays, and activities. As these results are compared to the existing literature it seems, that people strongly associate the risk related to travel mainly to this risk traveler defined by Odolini et al., and thus the risks for more "standard" and pre-booked holiday within mostly one destination are considered low. Therefore the need for increasing the information about the risks in touristic destinations and urban environment exist and must be noted.

As Mowford states, we all have our individual geographical imaginations which are affected by a variety of different factors such as sex, age, ethnicity, culture, and media (Mowford et al. 1998:7). In this case, touristic destinations seem to have an image of low-risk destinations amongst the Finnish travelers.

Perceptions of risk and protective measures taken

Surprisingly few were aware of the dengue risk in their destination beforehand of the travel. The fact that those traveling during the rainy season were slightly more likely to be aware of the risk indicates that maybe the risks that are related to the wet season are more available than risks during the “low risk” period. The willingness to use protective measures has been associated with traveling during the rainy season, which supports findings in this study as well (Lalani et al. 2016). Most of the travelers did not seek pre-travel advice for protection against mosquito bites, but among those who had, the information was received mostly through the internet. Google and Facebook-groups related to destinations were highlighted among the answers. This suggests that the information is sought through very easily reachable ways, and that information should be maybe more targeted to the population at risk than to assume that they will actively seek for it. This finding is quite opposite with studies carried out by Dahlgren et al. and Herck et al., who both argue, that the pre-travel advice is sought mainly from general or a private doctor. However, as these studies have been executed at the beginning of the 21st century, the role of the internet has significantly increased since.

The fact that the second most popular way of getting information was via friends and family, or via their own previous experiences, supports the thought that people are not actively seeking information on travel-related health risks. This is in line with the results in multiple other studies as well of people relying on their own experiences instead of looking for pre-travel advice (van Genderen et al. 2012:6, Dahlgren et al. 2006:1076, Herck et al. 2004). Notable is that if people sought pre-travel advice, they were up to 34.9 times more likely to use protective measures than those who did not. This has been studied before and it is known that those seeking pre-travel advice are more likely to be aware of mosquito-borne diseases and to use protective measures (Cherry et al. 2016). For example, a study conducted by Lalani et al. (2016) had participants receiving pre-travel advice prior to departure and were more aware of the day-active mosquitoes and that there was no need for bed nets in regions with dengue risk. This underlines the importance of available information, that travelers firstly know what to look for, and that they have access to updated and comprehensive information. In this case, these results don not only highlight the role of pre-travel advice, but also the fact that right knowledge needs to be easily reachable.

It must be considered that the type of trip the responders engaged possibly had an effect on risk perception. People traveled for holiday and spent their time on a beach, by the pool or in a city, which are environments that are not generally perceived as places with either health risks or mosquitoes around. It seems that this type of travel is thought not to include such health-related risks, that travelers should in some way prepare themselves prior to their departure. In addition to the type of travel, the lack of knowledge about dengue could be seen from the results regarding the protective measures taken. The majority stated that they had used some measures, but interestingly enough, the fact that the travelers were aware of mosquitoes or their bites was not statistically significantly associated with applying protective measures. This is opposite with results by Lalani et al. (2016). Moreover, females were more likely and willing to use protective measures than males, as was found out in the studies by Hasler et al. (2019) and Lalani et al. (2016) as well. They too highlight the importance of access to pre-travel advice that covers the correct use of anti-vectorial protective measures (Hasler et al. 2019, Lalani et al. 2016).

When asked more specifically when and how responders protected themselves, the majority had used measures on the wrong time of the day and thus measures had been chosen accordingly to those hours. More than half who used some protective measures said that they applied effective mosquito repellent, this being the most popular way of protecting oneself from mosquitoes. This finding is in line with Hasler et al. (2019) results with 58 % of travelers intending to use effective repellent on skin. They also conclude, that only 2.5 % of travelers actually used the repellent correctly by applying the right amount of it and frequently enough. Even though the fact of how often during a day the travelers applied the repellent wasn´t asked on this study, it can be inferred that mainly it wasn´t sufficient enough. In addition, many used protective measures during evenings and nights, which indicates that they were either unaware of the day-active mosquito or protected themselves against malaria. The unnecessary worry towards malaria amongst those traveling to no-risk destinations has been shown in other studies as well so this not surprising (Herck et al. 2004).

VIEWPOINTS FOR PUBLIC HEALTH

Based on these results the lack of risk perception for dengue risk was apparent among Finnish travelers who have acquired dengue infection. Furthermore, the gap in the knowledge of day-active mosquito was apparent as it seems that the protective measures had been taken mainly towards malaria. In some cases, the knowledge that dengue is transmitted through mosquitoes was completely missing and it was thought that the virus had entered through a small wound. In addition, the uncertainty of how to use mosquito-repellent in the right way was also presented among the responders.

These in mind, the knowledge needs to be increased about dengue risk in popular touristic destinations, such as Thailand, Indonesia and, the Maldives. In order to do so, people need to be aware of what dengue is as a disease and that how it is transmitted. This could be highlighted through the fact that there are day-active mosquitoes that thrive in urban environments in especially Asian destinations and that these mosquitoes transmit different infectious diseases such as dengue and chikungunya. Even though chikungunya is not part of this study, it is useful to increase knowledge about other tropical vector-borne diseases as well. Especially when these diseases are emerging and people are not adequately aware of them.

Adding to this, the right way of using protective measures has to be emphasized. Taking measures during evenings and nights doesn´t provide any protection against *Aedes*- mosquitoes and the diseases they carry. The right use of effective mosquito repellents needs highlighting as well as the information of when, how much and how often repellent has to be applied. These instructions might be hard to give precisely, but the fact that the repellent has to be applied more than once a day could be further addressed. Also, the way of applying it as well as the amount and the right effectiveness of repellent could be accentuated. Further studies of Finnish travelers’ knowledge, attitudes, and practices in regards to risk perception and the use of repellents should be conducted to gain more knowledge from the topic.

Most of the responders did not actively seek pre-travel advice of protection against mosquitoes. Thus the communications could be planned so, that information reaches the travelers without them actively seeking it. One way of doing this would be, for example by using social media to reach the groups with potential travelers. Tools could be either sharing a visual information sheet or other easily interpreted documents or by using targeted advertising to reach the population in need of information.

In a longer run, the general information of dengue, day-active mosquito and the ways to use effective mosquito repellent needs to be easily reachable through the internet. As well as increasing the knowledge among Finnish travelers, the knowledge needs also to be increased among the healthcare workers. If travelers do seek pre-travel advice, they need to be informed about the potential risk for infectious diseases transmitted by a day-active and urban mosquito in addition to information on possible malaria risk and the knowledge about vaccine-preventable diseases. Finally, the information whether the acquired dengue infection will affect one´s safety to travel to dengue endemic destinations in the future needs to be more effectively communicated with the patients to prevent unnecessary concerns among them.

LIMITATIONS

Limitations of this study can be considered to be firstly the missing information of 39% of travelers from the study period of January 2016–May 2019. However, 61% can be considered as a particularly high response rate, and thus the data is relatively good. As mentioned, the age of those participating in this study was slightly higher than among the original data. This can distort the findings of the general type of the trip or the way people travel.

In addition, this study was conducted based on diagnoses done in Finland, thus the diagnoses done within the destination countries are not included. It can only be speculated if this would change the results or not. Maybe the travelers who engage longer trips through multiple countries are the ones who seek medical care during their trip. Incubation period considered, people who get infected more than a week before returning home would be the ones seeking medical care during the trip and not after returning to Finland. However as stated, this is only speculation as there is no information available about these diagnoses. In addition, it must be noted that most of the dengue infections are not manifesting clinically and thus remain not documented.

Among studies related to travel health, the retrospective method has been noted to cause a notable lack of data regards of living standards and the traveling habits of the patients. Also, the unrealistic optimism and social pressure can affect to these results, as these factors have been seen to effect on studies focusing on knowledge, attitudes, and practices. These matters have been noted, as well as the fact that responders might remember asked details incorrectly. In order to form a more thorough picture of the risk of whether or how travelers use protective measures and how this affects the risk of contracting dengue, a questionnaire filled before and after the trip to dengue-endemic destinations would provide valuable information. Also, as the risk is not equal around each destination country, to gain a more comprehensive picture it would be interesting to calculate attack rates for individual regions, especially within Thailand. However, there is no travel data for each region and thus this is not possible.

With crude attack rates, the limitations caused by travel data affect the calculated numbers. UNWTO tourism data was available only for the first two years of the study data (2016–2017) and thus ARs were only calculated for the whole study period using the mean number of travelers during these years and possible changes during the past two years can´t be seen. For this reason, there are some uncertainties with the results, as the numbers of arrivals may have changed significantly within some of these destinations. A good example being the Maldives, where the increase in arrivals between 2016 and 2017 is already notable, and thus if the increase in travelers has continued the same trend, the AR calculated for the Maldives might be higher than it actually is. This as well as the fact that from some countries the number of acquired infection was very low affecting to the width of confidence intervals. Thus these numbers must be looked at with caution. However, even though there are uncertainties in these numbers, we can still form an overall picture of the risk Finnish travelers encounter during their trips to these destinations.

Lastly, as dengue has been a notifiable disease in Finland since 1999, the numbers reported annually might be affected by the fact that the knowledge has been increasing over time.

CONCLUSIONS

As there have been no previous studies concerning the backgrounds of dengue infections in Finnish travelers, this study fills the gaps in knowledge and provides information on which possible intervention strategies can be based on. To gain a comprehensive picture of the backgrounds, there were three main objectives for this study. 1) To examine the countries where the dengue infections were imported from and the risk within these countries. 2) To find out the factors associated with the risk of acquiring the infection and to define the group at the highest risk for infection. 3) To investigate the risk perceptions and the protective measures taken in order to minimize the risk of acquiring the infection. These problems were answered based on the data from the National Infectious Disease Register and the questionnaires sent to all individuals who had acquired dengue infection from 2016 to May 2019. With a 61.3 % response rate the results can be considered reliable and reflecting the reality. All these factors considered, the major novelty of this study lies within the comprehensive overall picture of dengue infections in Finnish travelers.

Based on this study there is some minor evidence that the level of endemicity is reflected in dengue infections in Finnish travelers. However, this would need further research. Most likely the places where the infections are contracted reflect the habits of Finnish tourists rather than true variations in disease activity. Moreover, based on these results the definition of travelers at risk is reflected more to the tendencies to travel than to the actual definition of risk traveler. It must be noted, that the definition of risk traveler provided here is solely dedicated to Finnish travelers at the risk of dengue.

In regard to risk perception and the protective measures taken, these results were smoothly in line with international studies when it comes relationship between risk perception, pre-travel advice, and application of protective measures. Clear gaps in knowledge could be identified in the time and the way of applying protective measures. Based on these findings, intervention methods can be distinguished and effectively targeted in order to increase the knowledge and hence the perception of dengue risk as well.

As there are no previous studies from this topic in Finnish traveler’s context, there is a further need for such studies with dengue, other vector-borne diseases as well as infectious diseases in general. The attitudes towards travel health among Finns have been studied very little and this as well needs further research. What it comes to dengue and the protective measures taken in order to prevent mosquito bites, a short cohort-study with questionnaires could be an advisable way of researching the attitudes and intentions prior to travel and after returning back home to see how the measures were actually applied. This could be done by interviewing the travelers at the airport before their departure to dengue-endemic countries and then contacting them after they return with another questionnaire.

Finally, as climate change will be progressively affecting the distribution of different infectious diseases as well as vector-species, the need for studies related to places of exposure and risk perceptions are constantly being emphasized. Consequently, the gaps in knowledge require to be identified in order to provide needed information for the target population to lighten the burden of these diseases. When it comes to the analyzing methods, in the context of public health GIS-tools are effective from making analyses to providing visual information for decision-makers. With mapping the disease at different levels, we can more comprehensively understand where it is present and which factors are affecting it whether the factor is related to climate, social structures or migration patterns. The crucial role of spatial presentation in the studies of the global movement of vector-borne diseases and infectious diseases in general, as well as the role of this study to the field of public health, can lastly be concluded with the words of Longley et al. (2011);

"Almost everything that happens, happens somewhere. Knowing where something happens can be critically important"

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APPENDICES

Annex 1. Questionnaire in Finnish

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VASTAA VERKOSSA
www.thl.fi/denguekysely

KYSELY DENGUEKUUMETARTUNNAN VUOSINA 2016–2019 SAANEILLE

Terveyden ja hyvinvoinnin laitos (THL) kartoittaa tällä kyselyllä suomalaisten matkailijoiden vuosina 2016–2019 saamien denguekuumetartuntojen taustoja. **Rengastakaa oikeaa vaihtoehtoa vastaava kirjain tai kirjoittakaa vastauksenne sille varattuun tilaan, ellei toisin mainita.** Epäselvissä tilanteissa, sekä mahdollisissa kysymyksissä voitte olla yhteydessä sähköpostitse henna.makela@thl.fi.

Jos huoltaja täyttää lomaketta alaikäisen puolesta, tulee huomioida, että kaikki kerättävät tiedot koskevat tartunnan saanutta.

TIEDOT MATKASTA

Täyttäkää tiedot mahdollisimman kattavasti sen matkan osalta, jonka aikana saitte denguekuumetartunnan.

1. Osaatteko sanoa, mistä maasta todennäköisimmin saitte denguekuumetartunnan?

A. Kyllä
B. En   Siirtykää kysymykseen 3

2. Maa, josta oletatte saaneenne denguekuumetartunnan: ______________________________

3. Kauanko matkanne kokonaisuudessaan kesti? Antakaa vastauksenne päivinä, viikkoina tai kuukausina *Esim. "7 päivää"*

____

4. Täydentäkää taulukko mahdollisimman tarkkaan aikajärjestyksessä sen mukaan, miten matkanne eteni. Määritelkää se kaupunki tai paikkakunta, jossa yövyitte tai näiden tietojen puuttuessa muulla tavoin se alue, jolla oleskelitte. Jos yövyitte saman maan sisällä usealla eri paikkakunnalla, täydentäkää paikkakunnat omille riveilleen. Arvioikaa alueella viettämänne aika niin tarkasti kuin muistatte. <u>Alleviivatkaa se paikka, jossa todennäköisimmin saitte denguekuumetartunnan.</u>

Kaupunki, paikkakunta tai alue	Maa	Kuinka kauan viihdyitte alueella *päivinä, viikkoina tai kuukausina*
Esim. Bangkok	*Thaimaa*	*3 päivää*
Esim. Siem Reap	*Kambodža*	*2 päivää*
Esim. <u>Etelärannikko lähellä Vietnamin rajaa</u>	*Kambodža*	*3 päivää*

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MATKAN LUONNE

5. Mikä seuraavista kuvaa matkaanne parhaiten? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Valmis-/pakettimatka
B. Omatoimimatka
C. Työmatka

6. Kenen kanssa matkustitte? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Yksin
B. Ystävän/puolison kanssa
C. Kaveriporukalla
D. Perheen kanssa
E. Jonkun muun kanssa. Kenen?____

7. Mikä oli matkanne pääasiallinen tarkoitus? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Lomamatka
B. Työmatka
C. Ystävien tai sukulaisten luona vierailu
D. Tutkimus/koulutus/opiskelu
E. Vapaaehtoistyö
F. Muu. Mikä? ____

8. Kuinka suuren osan majoituksistanne varasitte ennen matkaa? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Varasin kaikki/lähes kaikki majoitukset
B. Varasin noin puolet majoituksista
C. Varasin vain osan majoituksista
D. Varasin majoituksen vain ensimmäiselle yölle
E. En varannut mitään majoitusta

9. Mikä oli pääasiallinen majoitusmuotonne matkan aikana? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Hotelli
B. Hostelli
C. Sukulaiset tai ystävät
D. Teltta/muu ulkomajoitus
E. Muu. Mikä? ____

10. Mikä seuraavista kuvaa matkanne luonnetta parhaiten? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Kaupunkiloma
B. Rantaloma
C. Aktiiviloma
D. Reppureissu
E. Työmatka
F. Muu. Mikä?____

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11. Missä vietitte pääasiallisesti aikaanne matkalla? Valitkaa parhaiten matkaanne sopiva vaihtoehto

A. Kaupungissa
B. Maaseudulla
C. Meren rannalla
D. Uima-altaalla
E. Luonnossa, liikkuen merkityillä poluilla
F. Luonnossa, liikkuen merkittyjen polkujen ulkopuolella
G. Muulla tavoin. Miten?

____
____
____

12. Tarkentakaa tähän tarvittaessa lisätietoja matkanne luonteeseen liittyen.

____
____
____

SUOJAUTUMINEN

13. Tiedostitteko alueen denguekuumeriskin ennen matkaa?

A. Kyllä
B. En
C. En tiedä/en muista

14. Haitteko tietoa hyttysiltä suojautumisesta ennen matkaa?

A. Kyllä
B. En
C. En tiedä/en muista

15. Jos haitte tietoa hyttysiltä suojautumisesta ennen matkaa, mistä saitte tietoa? Ympyröikää sopivin vaihtoehto/ vaihtoehdot

A. Terveyskeskuksesta
B. Yksityiseltä lääkäriasemalta
C. Yksityisestä matkailuneuvonnasta
D. Työterveyshuollosta
E. Ylioppilaiden terveydenhoitosäätiöltä/muulta opiskelijaterveydenhuollolta
F. Ystäviltä/sukulaisilta
G. Internetistä
H. Muualta. Mistä?____

16. Jos haitte tietoa hyttysiltä suojautumisesta internetistä, luettele tähän ne sivustot joista muistatte hakeneenne tietoa.

____
____
____

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17. Suojauduitteko matkan aikana hyttysiltä?

A. Kyllä
B. En Siirtykää kysymykseen 20

18. Jos suojauduitte matkan aikana hyttysiltä, mihin vuorokaudenaikaan suojauduitte? Ympyröikää sopiva vaihtoehto/vaihtoehdot

A. Aamulla
B. Aamupäivällä
C. Keskipäivällä
D. Iltapäivällä
E. Illalla
F. Yöllä
G. Kaikkina vuorokaudenaikoina
H. En muista

19. Jos suojauduitte matkan aikana hyttysiltä, mitä seuraavista keinoista käytitte? Ympyröikää sopiva vaihtoehto/vaihtoehdot

A. Pukeuduin pitkähihaisiin ja -lahkeisiin vaatteisiin
B. Pukeuduin vaaleisiin vaatteisiin
C. Suojasin nilkat ja jalat sukilla tai umpinaisilla kengillä
D. Suojasin pään päähineellä
E. Käytin tehokasta hyttys-/hyönteiskarkotetta paljailla ihoalueilla
F. Hävitin hyttyset makuutiloista ennen nukkumaanmenoa
G. Nukuin ilmastoidussa huoneessa
H. Nukuin vuodeverkon alla
I. Jollain muulla tavalla. Miten?
____
____

20. Huomasitteko hyttyset ympäristössänne tai niiden pistot matkan aikana? Ympyröikää sopiva vaihtoehto

A. En huomannut kumpaakaan
B. Huomasin ainoastaan hyttyset ympäristössäni
C. Huomasin ainoastaan pistokohdat
D. Huomasin sekä hyttyset että niiden pistokohdat
E. En muista

TAUSTATIEDOT

Jos huoltaja täyttää lomakkeen alaikäisen puolesta, tulee huomioida, että kaikki tiedot koskevat tartunnan saanutta

21. Mikä on sukupuolenne?

A. Nainen B. Mies C. Muu

22. Mikä oli ikänne matkan aikana?

_______ vuotta

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23. Mikä on ammatillinen koulutuksenne? Ympyröikää korkein koulutuksenne

A. Ei ammatillista tutkintoa
B. Keskiaste, toisen asteen koulutus (lukio/ammattikoulu)
C. Alempi korkeakouluaste
D. Ylempi korkeakouluaste
E. Tutkijakoulutus

24. Mikä on ammattiasemanne? Ympyröikää sopiva vaihtoehto/vaihtoehdot

A. Työnantaja
B. Yksityisyrittäjä
C. Ylempi toimihenkilö
D. Alempi toimihenkilö
E. Työntekijä
F. Työtön
G. Kotiäiti tai -isä
H. Opiskelija tai koululainen
I. Eläkeläinen
J. Jokin muu. Mikä?____

25. Mikä on kansalaisuutenne?

A. Suomi
B. Jokin muu. Mikä?______________________

26. Kuinka usein vuodessa keskimäärin matkustatte ulkomaille? Ympyröikää sopivin vaihtoehto

A. Harvemmin kuin kerran vuodessa
B. 1–2 kertaa vuodessa
C. 3–4 kertaa vuodessa
D. Yli 5 kertaa vuodessa

27. Mikä on pääasiallisin matkustusmuotonne? Ympyröikää sopivin vaihtoehto

A. Valmis-/pakettimatka
B. Omatoimimatka
C. Työmatka

28. Voitte halutessanne vielä lopuksi täydentää tai selittää vastauksianne.

____
____
____
____
____

KIITOS VASTAUKSISTANNE!

Annex 2. The results of Welch t-test performed with R

```
	Welch Two Sample t-test

data:  tarkasteltavat$age[tarkasteltavat$Vastannut == "1"] and tarkasteltavat$age[tarkasteltavat$Vastannut == "2"]
t = 2.6286, df = 185.1, p-value = 0.009293
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.354792 9.506320
sample estimates:
mean of x mean of y
 39.55556  34.12500

> |
```

Annex 3. Overall crude attack rates and the 95% confidence intervals (CI) for most common destinations, 2016–2019

Destination	Number of arrivals *	Number of infections **	AR (CI 95%)
Asia			
Thailand	137,351	18.5	13.5 (8.3-20.7)
Indonesia	22,739	4.75	20.9 (7.1-45.0)
Maldives	3147	1.75	55.6 (7.7-176.9)
Vietnam	17,095	1.75	10.2 (1.4-32.6)
Sri Lanka	6742	1.25	18.5 (3.6-82.6)
India	19,378	1.0	5.2 (1.3-28.6)
Philippines	6638	1.0	15.1 (3.7-83.9)

** average of 2016 -2017*
*** average of 2016-2019*

Annex 4. Factors, odds ratios and confidence intervals of 95% for fitted regression models

Binary logistic regression model

Was aware of the risk for dengue

Factor	**Odds ratio**	**Confidence interval (95%)**	
Sex (female)	0.69	0.26-1.81	
Frequency to travel	0.85	0.45-1.58	
Pre-travel advice	4.00	1.58-10.85	**
Travel season (rainy)	5.38	1.64-20.24	**
Education	1.30	0.82-2.08	
Age	0.77	0.55-1.06	

**= P-value <0.001

Used protective measures against mosquitoes

Factor	**Odds ratio**	**Confidence interval (95%)**	
Sex (female)	3.56	1.24-11.16	*
Frequency to travel	0.70	0.34-1.37	
Sought for pre-travel advice	34.86	6.15-669.74	**
Risk percetion (aware)	0.91	0.25-3.14	
Education	1.34	0.79-2.32	
Age	1.04	0.75-1.43	
Awareness of mosquitoes during the trip	1.14	0.72-1.81	
Travel season (rainy)	3.08	0.67-18.52	

*= P-value <0.01 **= P-value <0.001

Annex 5. Median ages by the groups of how and when responders used protective measures

Protective measure	Used effective repellent on skin	Slept under bed net	Long sleeved clothing	Light-colored clothing	Covered ankles and feet	Covered head with a hat	Got rid of mosquitoes from bedroom before night	Used air conditioning during nights
Age (median)	37	34	36	44	33	32,5	40	36,5
N	62	11	17	6	3	6	22	46
Time of the day	Morning	Forenoon	Midday	Afternoon	Evening	Night	All hours	Don´t remember
Age (median)	31	31	29	26,5	38	37	36	32
N	9	7	6	14	54	20	12	5